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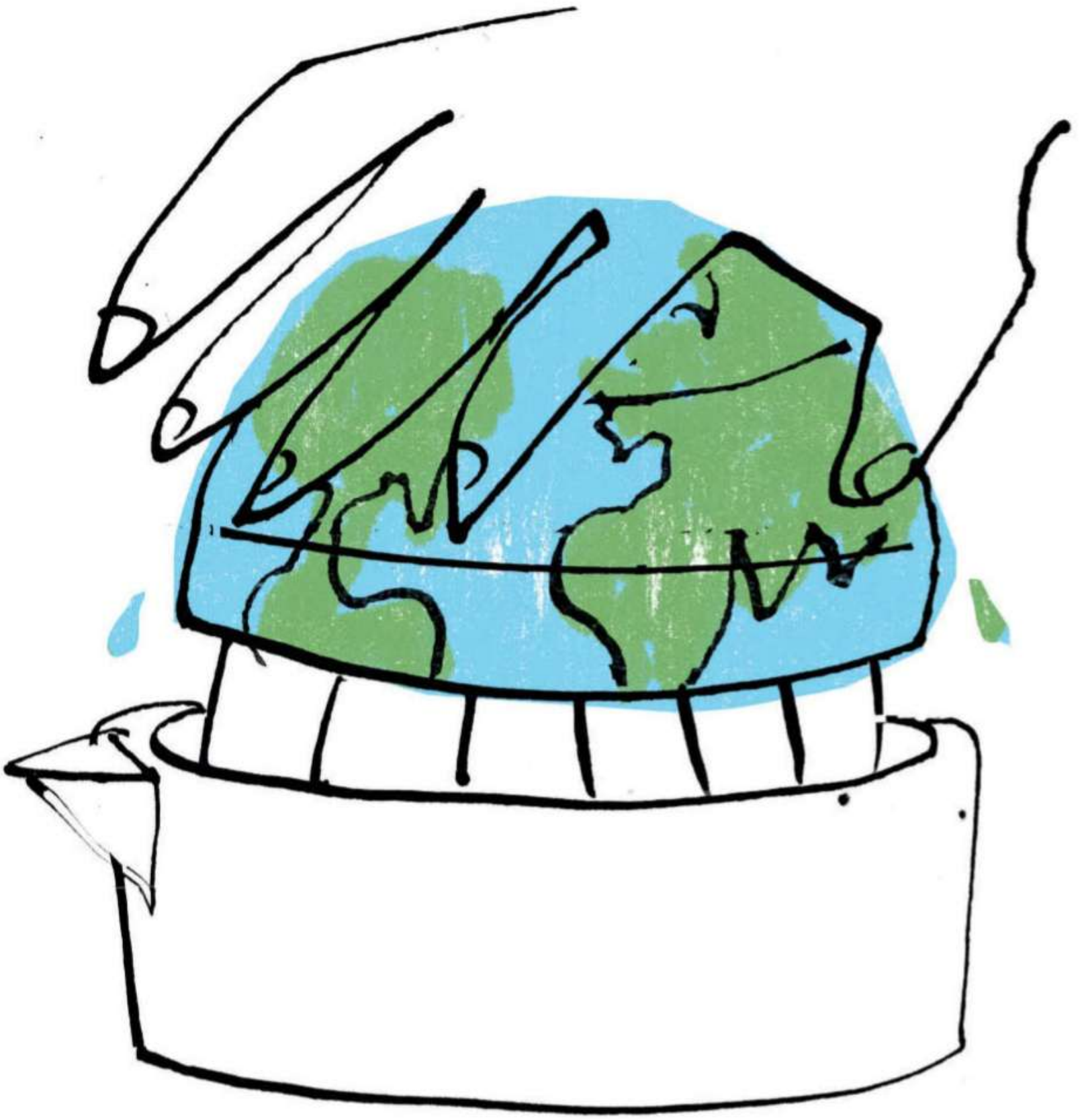

A five minute daily newsletter from the founder of The Week, that brings together all the things that matter from the world's best news sources.

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ERIC BACCEGA/NATUREPL.COM

Doctor, doctor Chimps treat each other with medicinal insects

Tour

Neanderthal Origins: Southern France

Step back in time to key Neanderthal sites with archaeologist Rebecca Wragg Sykes. See the oldest traces left by archaic humans, including stone tools and cave paintings.

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Podcast

Weekly

This week's episode was recorded live at Bluedot music festival. The team discuss extraterrestrial life, reveal news of chimp doctors and chat about how they would use $100 million to save the world.

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Newsletter

Fix the Planet

After a sweltering few weeks, senior reporter Adam Vaughan analyses the possible outcomes of the upcoming COP27 conference, our next big chance to limit extreme weather in the future.

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TikTok

Ancient art

Join reporter Alice Klein on her travels to Murujuga in Western Australia to see an incredible collection of ancient rock art. The area holds more than 2 million engravings.

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A note from the editor

Dear reader,

This is just to let you know – in case you have missed the adverts – that our flagship show, New Scientist Live, is back at ExCeL London this October after a two-year hiatus. If you have been before, I hope you can make it again this year. If you are new to the event, please let me assure you it is the highlight of everyone's year at *New Scientist* and, in our view, well worth a trip. Personally, I love going to as many of the talks as possible; hearing live from the world's top scientists and technologists fires me up for the next 12 months. I also love getting the chance to meet you, our community of readers, without whom we wouldn't exist.

This year, it is a three-day event over a weekend, with a schools focus on the Friday and then business as normal on the Saturday and Sunday. I am really looking forward to the "big" talks from the most high-profile guests, but the joy of the show is stumbling across a talk by a lesser-known scientist and being bowled over by it. For details of our early-bird ticket offer, please go to newscientistlive.com.

So, to this issue of our magazine. Our feature on cuneiform (see page 40) is one of my favourite cover stories so far this year. As part of the research for it, my colleague Alison George and I had the most enormous privilege of being allowed behind the scenes at the British Museum in London, where we got to inspect its vast collection of ancient clay tablets from Mesopotamia. Thank you to renowned cuneiform expert Irving Finkel for that visit; it was inspirational.

Another leading expert in this field is Enrique Jiménez, who also features heavily in our story (for which we owe him many, many thanks). He has provided these words, written in cuneiform, below. If you can decipher them, email me at editor@newscientist.com with your address and what you think they say. We will pick some winners out of a hat and send them something nice adorned with the words "New Scientist" as a reward. Be warned: cuneiform isn't for the faint-hearted!

All the best to you all,

Emily Wilson
New Scientist editor

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Welcome to our Signal Boost project – a page for charitable organisations to get their message out to a global audience, free of charge. Today, a message from **Hebridiean Whale & Dolphin Trust**

Hebridean Whale & Dolphin Trust

Sail with HWDT to protect whales and dolphins

There is still so much to learn about our seas and oceans; the creatures which inhabit that world beneath the waves and the challenges they face. Off Scotland's west coast, the Hebridean Whale and Dolphin Trust (HWDT) run a pioneering citizen science programme on board their research yacht, Silurian, gathering high-quality visual and acoustic data. The vital data collected is used to protect whales, dolphins, porpoises and basking sharks in Hebridean seas.

Each year, people participate in live-aboard expeditions, spending between 7 and 12 days at sea. These citizen scientists effectively become marine mammal field biologists for the duration, with full training provided on how to identify different species and undertake the monitoring work. People from all walks of life join HWDT on board Silurian, from teenagers to retirees – the experience is open to all.

HWDTs study area covers the west coast of Scotland, from Cape Wrath in the north to the Mull of Kintyre in the south and as far west as St Kilda. Expeditions rendezvous in Tobermory on the Isle of Mull or Mallaig and Ullapool in the Scottish Highlands. Each expedition will gather data from a different area and each night will be spent in a different location, providing a great opportunity to explore the area.

Over the last 20 years, thanks to the help of thousands of citizen scientists 130,000 km of Hebridean seas have been surveyed – equivalent of sailing five times around the world. More than 9,000 hours of underwater recordings have been collected. Over 50,000 individual animals have been observed from almost 16,000 encounters, with a count of 16 different species.

The vast volume of data collected on board provides a unique and powerful body of knowledge, which is boosting the protection of whales, dolphins, porpoises and basking sharks. The data has been instrumental in the identification and designation of marine protected areas – a national and global first for some species. It is also shared with other conservation organisations, researchers and Universities to help deepen our understanding of these awesome creatures.

Want to get involved?

Join an expedition in 2023 with HWDT and contribute directly to the protection of Scottish whales and dolphins by helping gather vital data. Explore the magical west coast of Scotland, have a positive impact on the area and an unforgettable experience. Find out more at: www.hwdt.org/silurian or contact morven.summers@hwdt.org.

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Biology's cup runneth over

AI can now reliably predict crucial information on vast numbers of proteins

"It has not escaped our notice..." With those famous words published in 1953, James Watson and Francis Crick described the fundamental genetic significance of the double-helix structure of DNA, based on work by Rosalind Franklin. It was a pivotal moment in biology, allowing us to understand for the first time how living organisms store the recipes for making proteins – the molecular machines that do most of the hard work in our bodies – and pass them down the generations.

Another major step forward came in 2001, with the draft sequence of almost the entire human genome. That revealed the big picture, that we have around 20,000 recipes for proteins, but not the detail of what they do. To fully understand proteins requires knowing their three-dimensional structure. These can be obtained experimentally, yet that is often a very slow process. Alternatively, computers can be used to try to predict structures from the gene sequence alone, but that used to be very difficult.

Used to be. In November 2020, Alphabet-owned DeepMind revealed that AlphaFold, its AI system for predicting protein structure, could accurately do this for pretty much any protein from its gene sequence. Now, it has released predicted structures of nearly all the more than 200 million known proteins (see page 10).

"Knowing protein structures can transform medicine and perhaps also food, farming and more"

This is another huge step forward in biology. Protein structures are never going to get as much attention as, say, dramatic images from space, but knowing them can have a much greater impact on our lives, transforming medicine and perhaps also food, farming and synthetic biology.

While the Human Genome Project rapidly transformed research, it was a decade or so before it delivered practical benefits like better treatments. We can expect something similar with AlphaFold.

Much work remains to understand how protein structures relate to their functions and how proteins interact with each other and with other molecules. The hope is that this will now accelerate, hastening our understanding of how life works at the molecular level, of the universe within. ▮

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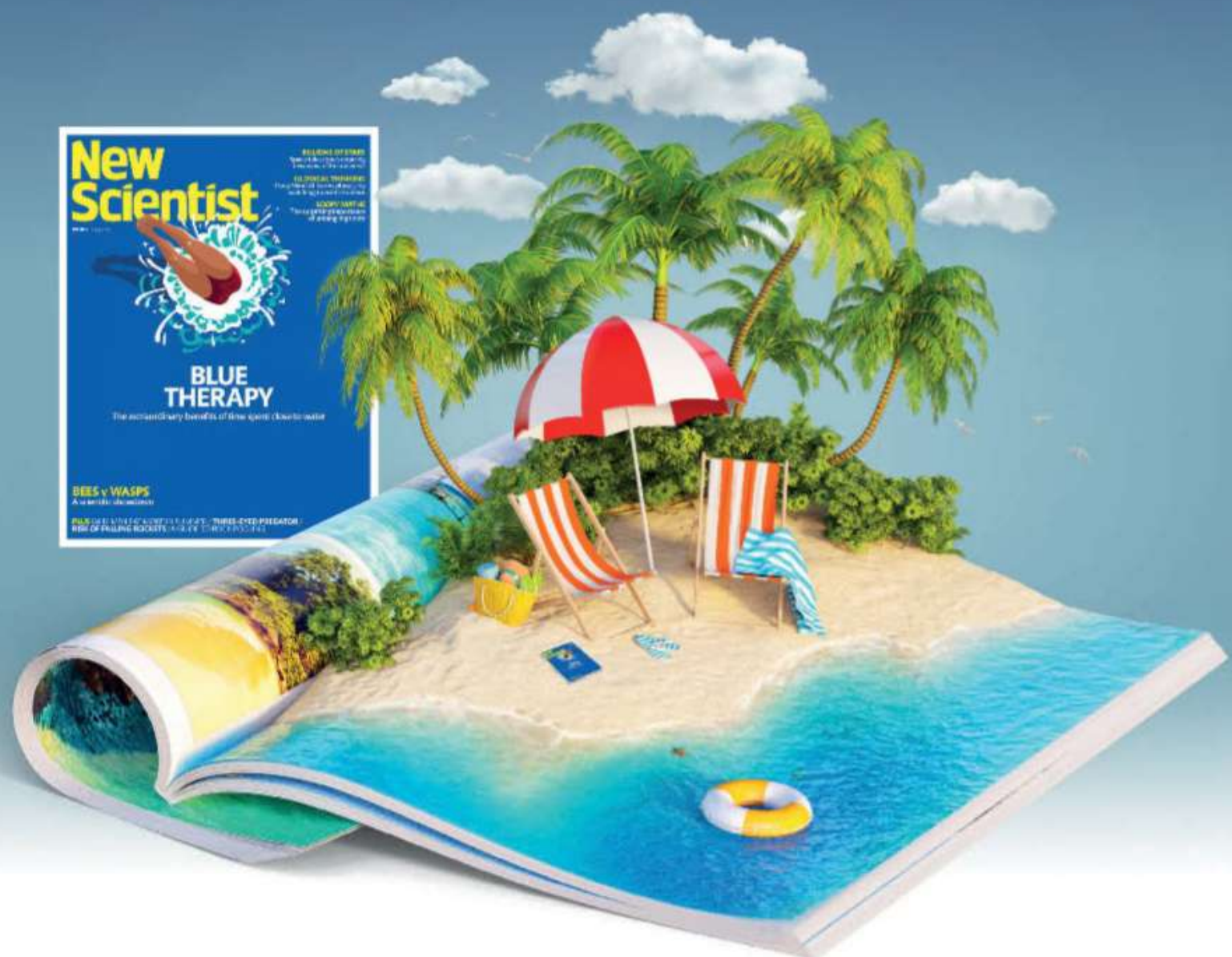

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WHO/LINDSAY MACKENZIE

WHO officials speak at a press conference on 23 July

Diseases

Monkeypox claims lives

The monkeypox outbreak's death toll is rising, but knowledge of symptoms is improving, reports **Jason Arunn Murugesu**

DEATHS due to monkeypox have been reported outside Africa for the first time in the current outbreak. On 29 July, a 41-year-old man from Brazil became the first person known to have died from the monkeypox virus outside the African continent in 2022. Two deaths in Spain were reported soon after. India reported its first monkeypox death, a 22-year-old man, on 1 August. Five deaths have been reported in Africa.

Monkeypox is typically a mild disease and people tend to recover within two to four weeks. But for some people, particularly those who are immunocompromised, it can be fatal.

There have been 23,620 confirmed cases of the disease globally as of 1 August, according to the US Centers for Disease Control and Prevention.

The vast majority of monkeypox cases outside Africa have been in men who have sex with men (MSM). Meanwhile, in Africa about 60 per cent of cases this year have been male, says Patrick Otim at the World Health Organization.

Previous outbreaks of the disease in Nigeria and the Democratic Republic of the Congo have had fatality rates of 3 to 10.6 per cent, says Otim. But the fatality rate of the current outbreak on the continent, as of 26 July, appears to be about 1 per cent, he says.

Although this figure is far lower than previous outbreaks, it is a lot higher than the fatality rate seen so far in the rest of the world. "About four people have died so far for 20,000 cases," says Paul Hunter at the University of East Anglia in the UK. "That's a fatality rate of about 1 in 5000."

"We need to ensure people know what the disease looks like and vaccinate high-risk groups"

Hunter says that may be due to the fact that about 20 to 40 per cent of MSM groups in most countries are HIV positive, but – unlike in Africa – the large majority of HIV positive people in the West have easy access to antiretroviral therapy, so are less likely to be immunocompromised.

Access to vaccines could be another factor. The UK is aiming to vaccinate all high-risk people in MSM groups, healthcare workers interacting with people with monkeypox and those who have been in close contact with confirmed cases. France and New York are using a similar strategy.

But this isn't the case in Africa. "Not a single dose of the monkeypox vaccine has been administered in Africa," says Otim.

Hunter says the number of deaths from the disease will continue to rise this year, but it is impossible to know how bad it will get. Chloe Orkin at Queen Mary University of London, who has studied global cases of the disease, estimates that 10 to 15 per cent of people who catch monkeypox will experience serious symptoms and be hospitalised.

The rise in deaths comes as researchers better characterise the symptoms. A study published on 28 July based on 197 monkeypox cases in the UK described symptoms that hadn't been observed in previous outbreaks, such as penile swelling, rectal pain and single lesions (*The BMJ*, doi.org/h6xc).

The UK Health Security Agency updated its list of known symptoms on 25 July. Orkin says health bodies around the world urgently need to do likewise.

Hunter says knowing the symptoms is key to controlling the outbreak. "We can bring monkeypox under control by the end of the year," he says. "We need to make sure people know what the disease looks like, ask people to moderate their behaviour until they've been vaccinated and vaccinate enough people in the high-risk groups." ▮

Artificial intelligence

Huge protein breakthrough

AlphaFold, an AI created by UK firm DeepMind, has predicted the structure of nearly all known proteins – a monumental feat, reports **Matthew Sparkes**

DEEPMIND has predicted the structure of almost every protein so far catalogued by science, cracking one of the grand challenges of biology in just 18 months thanks to an artificial intelligence called AlphaFold. Researchers say that the work has already led to advances in combating malaria, antibiotic resistance and plastic waste, and could speed up the discovery of new drugs.

Reliably predicting the complex shapes of proteins just from the sequences of amino acids they contain has been a challenge for decades in biology. Some of these amino acids are attracted to others, some are repelled by water, and the chains they form bend into intricate shapes that are hard to accurately decipher.

UK-based AI firm DeepMind, which is owned by Alphabet, Google's parent company, first announced it had developed a method to accurately predict the structure of folded proteins in late 2020. By the middle of 2021, it revealed that it had used this to map 98.5 per cent of the proteins in the human body.

On 28 July, the company announced that it was publishing the predicted structures of more than 200 million proteins – nearly all of those catalogued on the globally recognised repository of protein research, UniProt.

DeepMind has worked with the European Molecular Biology Laboratory's European Bioinformatics Institute (EMBL-EBI) to create a searchable store of all this information that can be easily and freely accessed by researchers around the world. Ewan Birney at EMBL-EBI calls the AlphaFold Protein Structure Database "a gift to humanity".

"As someone who's been in genomics and computational biology since the 1990s, I've seen many of these moments come where you can sense the landscape shifting under you and the provision of new resources, and this has been one of the fastest," he says. "I mean, two years ago, we just simply did not realise that this was feasible."

Demis Hassabis, CEO of DeepMind, says that the database makes obtaining a predicted protein structure "almost as easy as doing a Google search". That contrasts with the years it can take to get a structure experimentally.

The AI's predictions have already been used by scientists to advance research in a number of areas. Matt Higgins at the University of Oxford and his colleagues were researching a protein that they believed was key to interrupting the life cycle of the malaria parasite, but were struggling to map its structure.

"One of the experimental methods that we use is X-ray crystallography," says Higgins. "We cause the proteins to form into lattices, fire X-rays at them and get information from those X-ray diffraction patterns to see what the molecule looks like. But we were never able, despite many years of work, to see in sufficient detail what this molecule looks like."

But when AlphaFold was released, it gave a clear prediction of the structure of the protein that matched the information the researchers had already been able to glean. They have now designed new proteins that they hope could serve as an effective malarial vaccine.

"The database makes finding a predicted protein structure almost as easy as doing a Google search"

Birney says that using X-ray crystallography to map the structure of a protein is expensive and time-consuming. "That means that experimentalists have to make choices about what they do, and AlphaFold hasn't had to make choices," he says. "I think we can be confident that there are new experiments and new insights coming through due to AlphaFold, which will impact 'how does this particular parasite work' or 'why does this particular disease happen in humans', for example."

Researchers have also used AlphaFold to engineer new enzymes to break down plastic waste and to learn more about the proteins that make bacteria resistant to antibiotics.

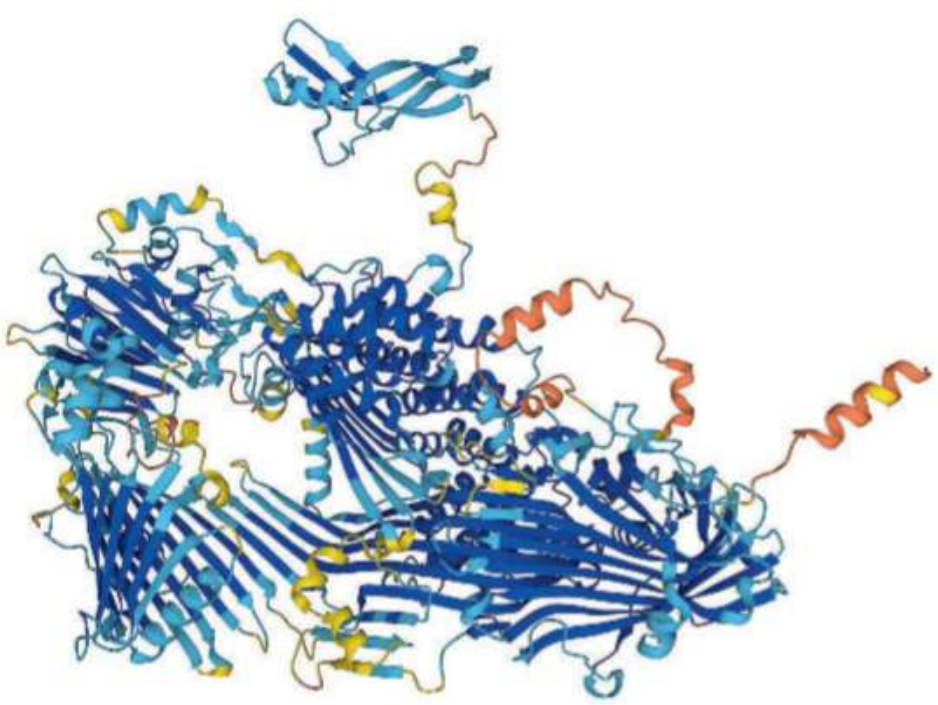
Keith Willison at Imperial College London says that AlphaFold has unarguably "changed the world" of biological research, but that there are still problems to be solved in protein folding.

"As soon as AlphaFold came out, it was wonderful. You just take your favourite proteins and look them up now, rather than having to make crystals," he says. "I did the crystallographic structure of a protein complex – it took me about eight years. People are joking that crystallographers are going to be unemployed."

But Willison points out that AlphaFold isn't able to take any arbitrary string of amino acids and model exactly how it folds. Instead, it is only able to use parts of proteins and their structures that have been experimentally determined to predict how a new protein will fold.

While the tool is usually, extremely accurate, its structures are always predictions rather than explicitly calculated results. Nor has AlphaFold yet solved the complex interactions that occur between proteins, or even made a dent in a small subset of structures, known as intrinsically disordered proteins, that seem to have unstable and unpredictable folding patterns.

"Once you discover one thing, then there are more problems



DEEPMIND

The structure of vitellogenin, an egg yolk precursor protein

thrown up," says Willison. "It's quite terrifying, actually, how complicated biology is."

Tomek Wlodarski at University College London says that AlphaFold has had an enormous impact on many areas of biology, but that there are improvements to be made on accuracy, and that developing a model of how proteins fold – not just predicting their final structure – is a problem that DeepMind is yet to tackle.

Wlodarski says AlphaFold isn't perfect, although it does indicate which parts of a prediction have a high accuracy and which it is less confident in.

"We introduced a mutation, which we know experimentally completely unfolds the protein, but AlphaFold gave me the same structure as it gave without this mutation," he says. "I did another test: I was removing residues from one end of the protein, because we know that with our protein, if you chop nine residues from one of the ends it will completely unfold the protein. And I managed to chop half of the protein sequence, and the algorithm still predicted it as a completely folded protein with exactly the same structure. So there are these problems."

Pushmeet Kohli, who leads DeepMind's scientific team, says that the company isn't done with proteins yet and is working to improve the accuracy and capabilities of AlphaFold.

"We know the static structure of proteins, but that's not where the game ends," he says. 'We want to understand how these proteins behave, what their dynamics are, how they interact with other proteins. Then there's the other area of genomics where we want to understand how the recipe of life translates into which proteins are created, when are they created and the working of a cell." ■

Why AlphaFold is transformational

Understanding the complex structures of proteins is key to developing drugs and knowing how living things work, says **Michael Le Page**

TO UNDERSTAND life, we need to understand proteins. Living things are molecular machines and most of the key components are made of proteins. You are reading this article, for instance, with proteins in your retina that can detect light, various proteins that make your muscles move and so on.

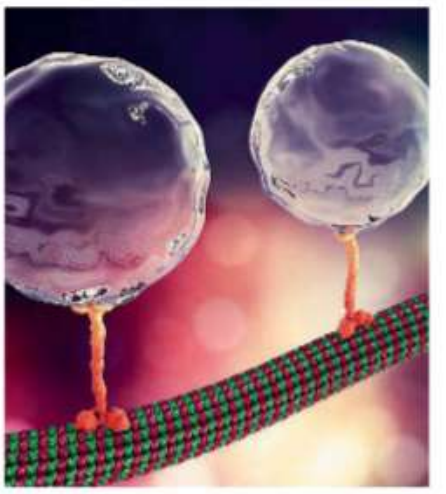
In one way, proteins are simple. They are made of chains that can contain up to 20 different amino acids. The sequence of amino acids in a chain is determined by the gene coding for a protein. Thanks to the cheap genome sequencing ushered in by the Human Genome Project, we now know the amino acid sequences of hundreds of millions of proteins found in viruses, bacteria, fungi, plants and animals.

In most cases, however, we still don't have a clue what most of these proteins do or how they do it. Techniques such as deleting a gene using CRISPR and seeing its impact on an organism can give us a good idea of what a protein does, but for the how, we need to work out a protein's shape, or structure.

Folded chains

Take kinesins, the cell's beasts of burden. These extraordinary proteins "walk" along cellular structures known as microtubules with two stubby "legs", pulling along cargoes attached to the other end of the protein. You just can't understand them without knowing their structures.

The problem is that a simple amino acid chain could, in theory, fold up into a vast number of different structures. In the past, determining the 3D structure of a single protein experimentally could take many years. Now, biologists can look at the predicted structure of almost any known protein in minutes, thanks to the database of over 200 million such structures released by DeepMind.



SHUTTERSTOCK/KATERYNA KON

Kinesins (illustrated in orange) are proteins that transport cargo inside cells by 'walking' along microtubules. Their structure helps us understand them

The protein structures and open-source tools previously released by DeepMind have already accelerated many areas of research. Already, more than 100 studies citing AlphaFold, its protein structure-predicting AI, are being released each month.

For instance, nuclear pores control the transport of molecules into and out of the DNA-containing nucleus of a cell. These pores are made of more than 1000 proteins and were poorly understood. But within months of the initial release of AlphaFold, researchers published a much improved model of the human nuclear pore.

Knowing protein structure is especially valuable for developing drugs. Most drugs work by binding to specific parts of proteins. This binding happens where part of the drug fits into part of the protein's structure, like a 3D jigsaw puzzle. If you know the protein structure, you can design drugs to fit, rather than relying on trial and error.

180k
Proteins whose structures have been found experimentally

200m
Protein structures that have been predicted by AlphaFold

100
Number of studies citing AlphaFold released per month

Treasure trove

It is worth noting that DeepMind has made its database of protein structures freely available. It could have chosen to follow a similar route to Celera, the company that tried to sequence the human genome before the publicly funded project so it could commercialise the data. It isn't clear if or how DeepMind intends to make money from AlphaFold, but what is clear is that the treasure trove of structures it has released will greatly accelerate many areas of research.

That said, it would be wrong to suggest the problem of determining protein structure is completely solved. The accuracy of AlphaFold's predictions vary, and for drug development in particular, accuracy really matters.

And as with the Human Genome Project, it is likely to take many years before the advances made with the help of AlphaFold result in treatments and products that benefit people directly.

But we have made far more progress in solving one of the toughest problems in science (see article left) than most researchers imagined was possible two years ago. Biology will never be the same again. ■

Distant galaxies

The race for the furthest galaxy

The James Webb Space Telescope keeps breaking its own record for the most distant galaxy ever found, reports **Leah Crane**

AS THE James Webb Space Telescope (JWST) has begun sending back its first science data, researchers around the world have reported new galaxies, each more distant than the last.

The distance to a cosmic object is denoted by what is known as redshift. This works a bit like the Doppler effect, in which a sound seems to change in pitch depending on whether it is moving towards or away from the listener. The faster a galaxy is moving away from the Milky Way, the higher its redshift – and because of the expansion of the universe, the more distant a galaxy is, the faster it moves away from us and the redder it looks.

We knew JWST would spot incredibly distant objects, with correspondingly high redshifts, but the immediate cascade of such distant galaxies it has revealed was surprising to many astronomers. "I don't think any of us really expected to see quite this many sources at such high redshifts," says Guido Roberts-Borsani at the University of California, Los Angeles. "We all expected to be surprised in some way or another, but not so quickly or so drastically."

Before JWST, the most distant object spotted had a redshift of about 11, meaning it formed within about 400 million years of the big bang. JWST has now been used to identify several galaxies with apparent redshifts of 13 and even higher, meaning they formed within 300 million years of the big bang (arxiv.org/abs/2207.12474).

So far, we don't know much about these galaxies, and most of their redshifts haven't yet been confirmed. "Right now, we're just grabbing all the fruit. We still have to figure out which are the good ones and which are the rotten ones, but right now, it's just gimme gimme gimme," says Jane Rigby at NASA's Goddard Space Flight Center in Maryland. "We're still in the initial harvest stage, and we don't really know what's important yet."

"We all expected to be surprised in some way or another, but not so quickly or so drastically"

"It's really quite an amazing mess right now, but it's been this sudden lurch forward and then we'll take some time and take a breath," says Rohan Naidu at the Harvard-Smithsonian Center for Astrophysics. After a whirlwind of new findings, the tough task of double-checking everything will begin, generally by taking more detailed measurements of the objects' light in a process called spectroscopy.

That will be particularly important for the most distant candidates. For example, a team led by Haojing Yan at the University of Missouri claims to have found a galaxy at a redshift of 20, so it would have to have formed within 180 million years of the big bang – far earlier than we expect galaxy formation to have begun (arxiv.org/abs/2207.11558).

"Our results are completely unexpected and are at odds with all previously favoured predictions," says Yan, who declined to comment on the details of his team's work before it is peer-reviewed.

"That, essentially, would break galaxy evolution," says Roberts-Borsani. If there really is a galaxy at a redshift of 20, it could mean that we have deeply misunderstood the physics of galaxy and star formation in the early universe.

"The capabilities of Webb are such that it could observe a redshift-20 thing if it were there, but there's a lot of scepticism whether it could be there," says Nathan Adams at the University of Manchester in the UK. "Something that extreme needs a closer look and validation from multiple people."

How did it all begin?

It might take a while to get that closer look. JWST's schedule is booked far in advance, and so is the other telescope big enough to do the necessary spectroscopy, the Atacama Large Millimeter/submillimeter Array in Chile. So unless researchers can convince the directors of those telescopes to let them skip the queue, these observations will have to wait.

Even before the necessary checks, it is clear that there are at least some galaxies that are brighter and more distant than expected. "If even 20 per cent of the galaxies reported in the last week turn out to be at the redshifts that they are reported to be at, it's strong evidence that these things form very early and very quickly, and get very massive and very bright very early," says Naidu.

Once we know which of these galaxies are real and formed in the extremely early universe, we can start studying them in more detail. "In the big picture, we're asking, how did it all get started?" says Rigby. "How quickly do galaxies stop being boring places of just hydrogen, helium and dark matter and start actually making the rest of the periodic table that we're made of?" ■

NASA, ESA, CSA, STSCI

A grouping of galaxies called Stephan's Quintet as seen by JWST

Exoplanets

New telescope could tell us what exoplanet surfaces are made of

Alex Wilkins

THE James Webb Space Telescope (JWST) may be able to give us a glimpse of the surfaces of rocky planets outside our solar system, as well as their atmospheres.

One way of measuring the atmosphere of a distant planet is to watch as it passes, or transits, in front of its star. As light passes through the gases that envelop a world, molecules absorb certain wavelengths of light, helping astronomers figure out the composition of its air.

Measuring the surface of a planet is trickier. Light reflecting off it will also carry information on its make-up, but it has to pass through the atmosphere, making it hard to figure out what they are both made from. The reflected light will also be weak, so noise can be a problem. So far, no one has managed to accurately determine the make-up of an exoplanet's surface – but this could be about to change.

"With JWST, hopefully, the noise floor should be low enough that we'll be able to disentangle which of those features are coming from the surface of the planet and which are coming from the atmosphere," says Emily Whittaker at the University of California, Los Angeles.

NASA, ESA, CSA, DANI PLAYER (STSCI)

Illustration of the exoplanet LHS 3844b and its host star

In an effort to prepare for JWST's exoplanet observations, Whittaker and their team have practised with data taken by the Spitzer Space Telescope of LHS 3844b – a planet that is hot like Mercury – as it passed in front of its host star. The heat means the planet's surface produces a strong signal, one that is unaffected by its sparse atmosphere.

The researchers created artificial signals from a variety of different surface and atmosphere compositions and then compared them with the telescope data to work out the make-up of the surface. The most likely scenarios involved rocky ground dominated by iron, with varying amounts of other metals like magnesium and calcium in different forms (arXiv, doi.org/h6vk).

"What we can already say just looking at this planet is yes, JWST will be able to characterise some surfaces, but what we're finding is that the surfaces that we will be able to characterise are the more reflective ones," says team member Matej Malik at the University of Maryland.

The planets we can observe might share similarities with bodies in our solar system such as Mercury or the moon, which have dark surfaces, but with brighter, spotty regions, says Malik.

The TRAPPIST-1 planetary system, which is around 40 light years from Earth, could be a prime target for this technique. "It's not something that's only applicable to LHS 3844b," says Raymond Pierrehumbert at the University of Oxford. "TRAPPIST-1b is a hot planet which is certainly rocky, and potentially a nearly bare rock with a wisp of atmosphere."

This ability to potentially distinguish the signatures of atmospheres and surfaces is innovative, says Pierrehumbert, and makes observing some exoplanet surfaces within the "margins of feasibility". ■

Galaxies

JWST spots a weird galaxy with almost no heavy elements

THERE is a strange, metal-poor galaxy lurking in the distant universe. The very first image released by the James Webb Space Telescope (JWST) team revealed a galaxy with far fewer heavy elements than we would expect, which may mean it is sucking up pristine hydrogen gas from intergalactic space.

Mirko Curti at the University of Cambridge and his colleagues examined the light from three galaxies shown in JWST's first deep-field image to measure the abundance of elements that astronomers call metals, meaning anything heavier than hydrogen. These heavy elements are formed in stars, which distribute them throughout space when they die.

Two of the galaxies the team examined were about 29.4 billion light years away from Earth, while the third was around 30.2 billion light years away. The nearer galaxies had fewer metals than galaxies in our part of the universe, as expected, but the further one had almost no metals at all – just 2 per cent of the metal content of the sun (arxiv.org/abs/2207.12375).

"This is one of the most extremely metal-poor objects that we have ever seen," says Curti.

Spotting such an odd galaxy so soon into JWST's observation run was a surprise. "No one was expecting to immediately see evidence for this extremely metal-poor galaxy in the very first data," says Curti.

"This galaxy is one of the most extremely metal-poor objects we have ever seen"

In the local universe, a galaxy's metal abundance is closely linked to its mass and rate of star formation, but this galaxy seems to buck the trend. That probably means it recently underwent some sort of dramatic change, says Curti, possibly swallowing up hydrogen gas from the space between galaxies.

As we get more detailed observations of other distant galaxies, researchers will be able to figure out whether such metal-poor galaxies are common or if this one is an anomaly. ■ LC

Wildlife

How pobblebonk frogs handle acidic pools

Jake Buehler

AUSTRALIA'S scarlet-sided pobblebonk frog thrives in waters so acidic they should be deadly, with its tadpoles tolerating water with a pH within the range of human stomach acid. This may be thanks to the frogs' heightened ability to draw dissolved calcium from the water into their gills.

Freshwater lakes and streams typically fall into the neutral range of 6 to 8 on the pH scale. But naturally occurring, highly acidic freshwater ecosystems are found around the world, says Rebecca Cramp at the University of Queensland in Australia.

In eastern Australia, there is the Wallum – a sandy, coastal region whose swamps and lakes can plunge below pH 3. Many creatures have adapted to such acidic ecosystems, including the Wallum's scarlet-sided pobblebonk frogs (*Limnodynastes terraereginae*), whose tadpoles tolerate water about 32 times more acidic than the level that kills most frog species.

pH 3.5

The acidity of lakes that pobblebonk frogs can thrive in

Low pH is normally detrimental for fish and amphibians because it causes cells in their gill lining to pull apart and lose sodium ions.

"The gills become leaky, and then the animal dies because it loses all its salt," says Greg Goss at the University of Alberta in Canada, who wasn't involved with the research.

Calcium is a crucial component of the junctions that hold gill lining cells together, so Cramp and her colleagues investigated the role of calcium ions in granting the pobblebonk its acid-thwarting powers. The team collected clumps of hundreds of

BEN REVELL

A scarlet-sided pobblebonk frog in Queensland, Australia

pobblebonk eggs from Bribie Island, Queensland, and raised the frogs in the lab. "[The frogs'] ability to actually thrive at pH 3.5 is phenomenal and something that we marvel at still," says Cramp.

The researchers put some of the tadpoles in acidic water and others in acidic water with extra calcium. After seven days, they measured the amount of sodium ions present in their bodies and the surrounding water. The tadpoles in low pH water with extra calcium lost fewer sodium ions than those in acidic water without calcium added, hinting at calcium's protective role in acidic environments. Moreover, when the tadpoles were exposed to ruthenium red – a compound that interferes with channels that allow cells to take up calcium – the frogs lost their acid tolerance, leaking large amounts of sodium (*Journal of Experimental Biology*, doi.org/h6vg).

The researchers think the tadpoles can supply the junctions between gill lining cells with a reliable stream of calcium by sucking it up from the water and storing it in cells, which stabilises the lining in acidic conditions. ▮

Chemistry

Forensic fingerprinting technique could help spot document fraud

Karmela Padavic-Callaghan

A METHOD for determining whether a fingerprint appeared on a piece of paper before or after text was printed on it could help resolve fraud cases. The approach uses standard forensic tools and so would be simple to put to use.

In forensics, the "when" is often as important as the "who". In a case, there could be a situation where someone is suspected of tampering with a will or contract by printing on top of it, for example. Determining when someone's fingerprint was made on the document could bolster any other evidence of tampering, says Roberto King at Foster + Freeman, a forensic instrument company based in the UK.

King and his colleagues have now created a technique that goes some way to achieving this. It lifts the print using a thin layer of gelatin, which reacts differently if the fingerprint was left on the paper before or after printing.

To use the technique, a technician places the gelatin over a fingerprint that overlaps with some printed text. They then peel off the gelatin and place it inside a vacuum-sealed glass box filled with a vapour of a chemical called disulphur dinitride. This vapour binds to the microscopic fingerprint ridges imprinted on the gelatin's surface so that after a few minutes, a blue-coloured fingerprint is revealed.

The team tested this process for a fingerprint that had text printed over it and another that was made on top of printed text. In the former case, the gelatin touched the text instead of the fingerprint first, so the pattern at the end of processing was noticeably different. The team could therefore tell whether the fingerprint or the text came first (*Scientific Reports*, doi.org/h6vn).

"This approach could be a much simpler and cheaper alternative to what has been proposed previously," says Melanie Bailey at the University of Surrey in the UK. Past experiments involved specialised instruments that may not be common in forensics labs, she says.

King says that crime scene examiners in the UK routinely carry gelatin lifters and that the rest of his team's process wouldn't require extensive further training. Additionally, the new technique can be combined with other forensic techniques, as gelatin lifting doesn't destroy the fingerprint, he says.

So far, the researchers have only tested combinations of fingerprints and laser jet inks, but they want to expand the method to other types of printing. They also want to extend it to writing with ballpoint pens, relevant for signature fraud, and stamps for possibly forged passports. ▮

Which came first, the fingerprint or the text in the document it was lifted from?

CULTURA CREATIVE RF/ALAMY

Health

Symptoms of chronic fatigue syndrome may be caused by mini blood clots

Grace Wade

PEOPLE with chronic fatigue syndrome may have tiny clots in their blood. These "microclots" could be responsible for symptoms including persistent exhaustion, pain and brain fog.

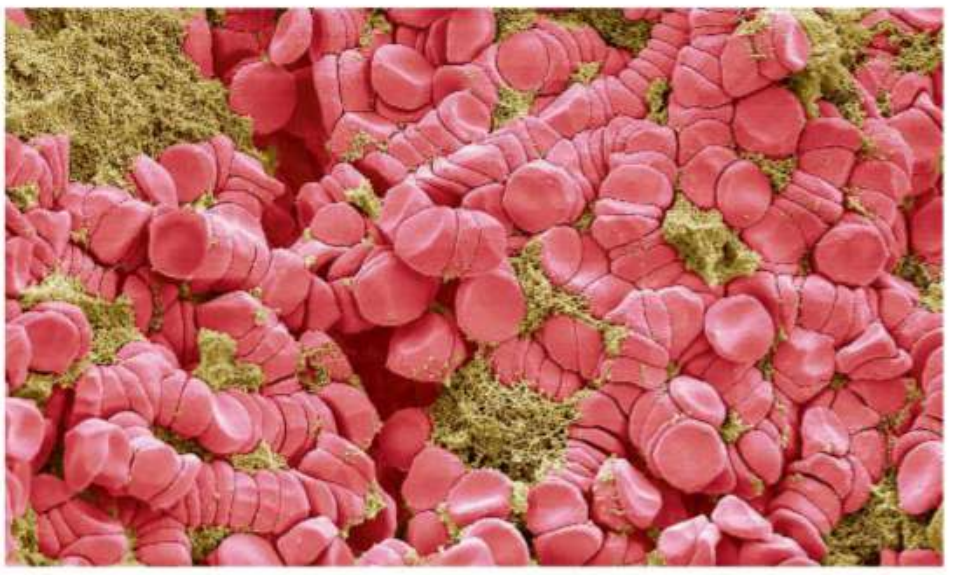
It is estimated that chronic fatigue syndrome, or myalgic encephalomyelitis (ME/CFS), affects up to 2.5 million people in the US, but little is understood about what causes it.

Microclots are clumps of blood platelets under 200 micrometres in diameter. Researchers have known for decades that these are found in people with conditions associated with inflammation, such as diabetes, Alzheimer's and rheumatoid arthritis. More recently, it has been found that blood samples from people with long covid can contain high concentrations of these small platelet clumps.

Since ME/CFS shares symptoms with long covid, such as headaches and lethargy, Resia Pretorius at Stellensbosch University in South Africa, Douglas Kell at the University of Liverpool in the UK and their colleagues wanted to see if microclots were also found in this condition. They analysed blood samples from 25 adults in South Africa diagnosed with ME/CFS who had symptoms for at least six months. These were compared with samples from 15 adults from the same area without ME/CFS or any condition known to increase the risk of clotting.

First, the team analysed the samples from people with ME/CFS for seven measures of abnormal blood clotting, such as clot size and clotting rate. Blood from 20 of the 25 people fell outside the normal range on at least one measure, and four people had abnormal results on five of the measures.

Microclots can reduce blood and oxygen flow, causing fatigue



STEVE GSCHMEISSNER/SCIENCE PHOTO LIBRARY

The researchers also used fluorescent staining to reveal the size and number of microclots under a microscope. Samples were graded on a scale of 1 to 4 with higher scores indicating more clotting. All control blood samples scored a 1, but 80 per cent of those from people with ME/CFS scored a 2 or higher; nearly half scored a 3 or 4. The concentration of microclots found wasn't as severe as you would see in people with acute or long covid, says Pretorius. But it was similar to diabetes and cardiovascular disease (*Pharmaceuticals*, doi.org/h6w8).

The finding provides a possible explanation for the exhaustion characteristic of ME/CFS, says Walter Ian Lipkin at Columbia University in New York. Microclots block small blood vessels. "[This] stops the ability of oxygen to get to tissues," says Kell, which undermines cell function.

It also validates that what people are experiencing is real. "A very large population of clinicians and psychologists say there is nothing physically wrong with individuals, it's all in their heads," says Pretorius.

It may also offer an avenue for treatment. ME/CFS may be a vascular clotting disease, says Pretorius. If future research confirms this, doctors may be able to use anti-clotting medications or other interventions to treat people with this condition, says Kell. ▮

Technology

Voice jammer stops anyone from recording you speak

YOU can now prevent the speech of a single target person from being recorded by using a voice jammer.

Voice jammers work much like noise-cancelling headphones, which effectively squash unwanted background sound waves out of existence by playing back a copy of the unwanted sound with its wave pattern inverted.

Such voice jammers generally stop electronic eavesdropping on conversations by broadcasting inverse sound waves that affect all microphones within earshot.

This can prevent nearby people's phones from picking up their voices if they try to make a call, and can stop them interacting with smart assistants, tipping people off that something strange is going on.

Now Qiben Yan at Michigan State University and his colleagues have created a voice jammer that can target a specific voice without causing disruption to anyone else. They did this by training an artificial intelligence called a neural network to isolate a speaker's voice, allowing the jammer to create an inverse sound matched to their speech.

Rather than transmitting an audible sound, their tool, called Neural Enhanced Cancellation (NEC), makes use of a bug found in all but the most expensive microphones. This bug introduces sounds at set distances above and below the microphone's recording frequencies. NEC is able to use this quirk to play its inverse speech in the ultrasonic range, so that humans can't hear it. Doing this at the point of recording provides the necessary frequencies to secretly block an audible voice (arxiv.org/abs/2207.05848).

"The voice jammer broadcasts in the ultrasonic range, so that humans can't hear it"

The team found that NEC blocked voices on a range of smartphones from Apple, Xiaomi and Samsung at a distance of up to 3.6 metres.

This technology could be useful for people like politicians, who may want to make sure a hidden microphone can't record what they are saying during a private conversation in public, says Yan. ▮

Matthew Sparkes

Coronavirus

Could vaccines end the pandemic?

Nasal vaccines may stem transmission, while universal ones could target proteins in every SARS-CoV-2 variant and even other coronaviruses, reports **Michael Le Page**

THE coronavirus vaccines have been a success, possibly saving tens of millions of lives. However, they haven't ended the pandemic and their effectiveness has been eroded by the evolution of variants of the SARS-CoV-2 coronavirus. A new generation of covid-19 vaccines is needed – but what exactly should this involve?

The US plans to roll out boosters that target the BA.4 and BA.5 omicron subvariants. Yet variant-specific boosters aren't going to be a game changer, not least because newer variants will have evolved before they are administered.

"The covid-19 vaccines are amazing and far better than we had a right to hope for"

Many researchers are aiming bigger: hoping to create vaccines that provide broad protection against many variants or to develop nasal vaccines that more effectively prevent infections – and preferably both combined.

Some immunologists think such second-generation vaccines could work so well that they stop transmission altogether, if enough people are vaccinated. "We have to be careful not to overpromise, but potentially there are huge benefits," says Ed Lavelle at Trinity College Dublin in Ireland.

The main ingredient of most existing covid-19 vaccines is the spike protein of the original SARS-CoV-2 from January 2020. This protrudes from the virus, helping it to enter cells. The technologies for packaging this protein vary, but the principle is the same. These vaccines are also all injected.

"The vaccines are amazing and far better than we had a right to hope for," says Danny Altmann at Imperial College London.

VINCENZO PINTO/AFP VIA GETTY IMAGES

Covid-19 vaccine vials being filled at Catalent Biologics in Italy

Yet they haven't stopped wave after wave of infections around the world. "Living with covid" is a problem for many reasons. While vaccines greatly reduce the threat of serious illness, they don't eliminate it. And with each reinfection, people are at risk of getting long covid.

Waning immunity

Why haven't the vaccines halted transmission? Part of the reason is that, by the time vaccines were rolled out, new variants – alpha, first detected in the UK, and beta in South Africa – had spike protein mutations that allowed them to partly evade immunity. In other words, the vaccine target – the spike protein – changes.

Jonathan Yewdell at the National Institutes of Health in Maryland says there is a more fundamental reason: no vaccine provides long-lasting protection against any virus that can be transmitted without the blood or lymph glands being involved. We should never have expected conventional vaccines to stop the pandemic, he wrote in 2021.

Take the measles virus, the most contagious virus we know, but also one that vaccines provide lifelong protection against. It doesn't initially infect the cells lining our noses and throats. Instead, it gets into immune cells in the lungs, which carry the virus to the lymph nodes, where it spreads in the body and is coughed or sneezed out when it reaches the airways.

Vaccinated people still sometimes catch measles, but given its convoluted route to the airways, the immune system has plenty of opportunities to intercept the virus before it is transmitted to anyone else.

By contrast, many respiratory viruses directly infect cells in the mucous membrane lining the airways. When the cells shed more viruses, these can infect other people. In the weeks after vaccination against many respiratory viruses, immunity may be high enough to prevent infection, but as this wanes, the risk of getting mucosal infections and passing them on rapidly increases.

One key factor is that mucosal immunity is different from the immunity that occurs in the rest of the body. Specific immune cells sit in the mucous membranes ready to detect and respond to pathogens, such as by secreting distinct antibodies. In fact, these membranes secrete vastly more antibodies than the rest of the body produces.

In general, injected vaccines produce strong overall immunity, but not mucosal immunity specifically, which is also true of mRNA covid-19 vaccines.

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Two main things must be done to create better covid-19 vaccines. The first is to create broadly protective, or universal, vaccines that the coronavirus cannot easily evade. The idea is to find parts of the coronavirus that can't change because they have a vital function, and get our immune system to focus on them. "If they are doing something important, the survival cost to the virus of mutating them will be incompatible with existence, and those are the ones you have to hit," says Altmann.

Next-generation vaccines

Although it might be theoretically possible to come up with a pan-coronavirus vaccine that protects against all kinds of these viruses and prevents future coronavirus pandemics, in practice, this is difficult. Despite decades of work, we still don't have a universal flu vaccine.

But lots of effort and money are being poured into developing universal coronavirus vaccines, with some teams reporting promising results in animals and a handful being tested in people.

One of the many challenges is to get the immune system to focus on a specific part of a protein that is shared by SARS-CoV-2 variants specifically or even other coronaviruses in the overall virus class. This can be achieved by including only small parts of these proteins in a vaccine. Another method is to include several different versions of the same protein – shared by different coronaviruses or SARS-CoV-2 variants specifically – to encourage our immune system to focus on the shared part.

"If you can generate an immune response in the gut, you might protect people from long covid"

A vaccine candidate developed in the US consists of viral particles that have eight versions of the same part of the spike protein protruding from them, one from SARS-CoV-2 and seven from animal coronaviruses. In animal tests, this protected against severe disease from several SARS-CoV-2 variants.

It didn't prevent infection, however, which may be hard to achieve with an injected universal vaccine.

Hence, the growing interest in the second main approach to improving vaccines: inducing strong mucosal immunity in our airways to stop infections taking hold and being passed on to others. The most powerful immune response is at the site of exposure, says Lavelle. For respiratory diseases, this usually means spraying a vaccine up the nose.

Only one intranasal vaccine has ever been approved: FluMist in 2003. There are several challenges with intranasal vaccination that have deterred vaccine-makers. One is getting vaccine proteins through the mucous membrane.

This requires larger doses, which can make such vaccines much more expensive, depending on the technology used. However, recent studies have shown that linking proteins to certain fatty molecules can help them penetrate the mucosal surface. One team recently reported that proteins modified like this induced mucosal antibody levels that were 1000-fold higher than those triggered by unmodified proteins.

THEMBA HADEBE/AP/SHUTTERSTOCK

A woman being vaccinated in South Africa

2020
When the covid-19 virus that vaccines are based on emerged

1000x
The increase in antibodies when viral proteins are modified

2003
The year the only intranasal vaccine, FluMist, was approved

SARS-CoV-2 sometimes infects the gut and boosting gut mucosal immunity appears to increase respiratory mucosal immunity too. Therefore, some groups are working on vaccines that can be swallowed in pill form. Certain cases of long covid may be due to persistent gut infections, according to Lawrence Young at the University of Warwick, UK.

"If you can generate an immune response in the mucosa in the gut, then you might protect people from some of the effects of long covid," he says.

As with universal vaccines, dozens of teams are working on mucosal covid-19 vaccines, with some excellent results in animal studies and several being tested in people. Combining the two approaches would prevent new variants from rapidly evading intranasal vaccines.

The big question is whether any such vaccines could block transmission altogether. Yewdell is doubtful, pointing out that our immune system isn't perfect. Others, including Lavelle and Altmann, think it is achievable.

But even if next-generation vaccines are good enough to achieve the long-sought-after goal of herd immunity, there is still the issue of getting enough people vaccinated. It will be easier to persuade people to get a spray up the nose than an injection, says Lavelle. ▮

BAY ISMOYO/AFP VIA GETTY IMAGES

People queuing for a vaccine in Jakarta, Indonesia

Security

Fraudsters in the US could use loophole to get material for a 'dirty bomb'

James Dinneen

AN INVESTIGATION in the US has found that someone using fake companies and fraudulent licences could obtain enough radioactive material to build a "dirty bomb", without ever having their credentials checked. Federal regulators don't have plans to fix the loophole in licensing rules until at least the end of 2023.

Dirty bombs use regular explosives to spread radioactive material. A 2017 Sandia National Laboratories report found a large dirty bomb detonated in lower Manhattan in New York could cause as much as $30 billion in damage. Even though no one would die immediately from the radiation itself, there could be as many as 1500 fatalities from the evacuation, such as from relocating vulnerable people.

In 2019, Congress member Bennie Thompson asked the Government Accountability Office (GAO) – a congressional agency – to investigate issues related to the security of radioactive materials following previous investigations that found vulnerabilities to how the materials are licensed. In the US, licensing is managed by the Nuclear Regulatory Commission and state governments.

To test the licensing process against fraud, GAO investigators set up two shell companies authorised to purchase radioactive material using fraudulent paper licences. Investigators then ordered radioactive materials from two different US vendors.

The quantity of material from each vendor was small enough that the vendors weren't required to verify licences before fulfilling orders. Together, however, the material from the vendors added up to a more strictly controlled "category 2" quantity, which is between 10 and 1000 times the amount of radioactive material needed to cause permanent human injury. If investigators had ordered a category 2 quantity directly, the vendors would have been required to verify the licence with the Nuclear Regulatory Commission or the state.

"Investigators set up two companies to purchase radioactive material using fraudulent paper licences"

GAO agents waited until the material was delivered before refusing each order, ensuring it was returned safely to the vendor.

Tara Sonenshine at Tufts University in Massachusetts says the report is "re-ringing an alarm bell" on inadequate controls around access to radioactive materials. Concerns about domestic terrorism and other violent acts make warnings about dirty bombs more urgent, she says. "We're living in a time of unfortunately worrisome scenarios." According to the GAO report, officials at the National Nuclear Security Administration believe there is increasing interest in making a dirty bomb.

A spokesperson for the Nuclear Regulatory Commission told *New Scientist* it has warned vendors to be vigilant of unusual activity and it has expedited the rule change, but immediately making a change "would risk unintended impacts to important and safe medical, academic and industrial uses of these materials". ■

Zoology

Moths are doing more pollinating than we thought

SHUTTERSTOCK/NATALIA ZAGAJA

The large yellow underwing (*Noctua pronuba*) pollinates red clover flowers

SPYING on the nocturnal activity of moths has exposed the insects' overlooked role in pollination.

Using 15 time-lapse cameras, Jamie Alison at Aarhus University in Denmark and his colleagues have recorded what happens in a meadow in the Swiss Alps, 24 hours a day, over a whole summer.

The team has found that moths account for 34 per cent of visits to red clover (*Trifolium pratense*), a wild flower that is a valuable forage crop for animals and has an important role in improving soil nutrients and structure.

The large yellow underwing (*Noctua pronuba*) was the moth primarily responsible for the flower visits. However, in over a century of research into red clover pollination, no mention of this contribution has previously been made.

Most studies looking at plants and insect pollinators have focused on a few bee species, meaning observation has almost exclusively taken place during the day.

Alison's team found that bumblebees made 61 per cent of flower visits – but dissection of the fruiting bodies of the red clover, and cross-checking them with camera footage, showed that those visited by bumblebees or moths or both produced 11.6 per cent more seeds than those without. No significant difference was seen for those only visited by bumblebees (*Biology Letters*, doi.org/gqj7tv).

"This is just one plant species, but it's been the subject of so much research. I'd wager that moths are thanklessly pollinating hundreds of less famous flower species across Europe," says Alison.

The study builds on previous work that measured pollen found on moths' bodies. "Technology has put us in a position where we can easily catch moths red-handed during pollination," says Alison.

Moth traps are being developed that use cameras linked to artificial intelligence-based identification, says Alison, which should reveal more of what moths are up to. ■

Gary Hartley

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AN IMPORTANT MESSAGE FROM PROFESSOR NICK LEMOINE CBE MD PHD FMEDSCI, CHAIR OF THE MEDICAL RESEARCH FOUNDATION

Gifts in Wills could be the key to protecting the future of human health

Our experience of COVID-19 shows how suddenly a global health challenge can appear. As someone interested in science, you will understand that while nobody can predict what we will face next, we can be certain that the future will bring many more threats to human health.

As Chair of the Medical Research Foundation – the charitable arm of the Medical Research Council – I have seen the incredible impact that individuals who remember the Foundation in their Wills can have on the future of our health and wellbeing here in the UK. These gifts fund research and researchers which can have far-reaching implications for human health.

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Right now, the Foundation is funding research to tackle antimicrobial resistance, and investing in researchers like Dr Myrsini Kaforou – who will make the fight against antimicrobial resistance her life's work.

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> **"As scientists, our duty is to secure the future of research for the generations that follow."**
>
> Professor Fiona Watt, Patron of the Medical Research Foundation and Director of the European Molecular Biology Organization.

While we don't know what the future holds for human health in the UK, we do know that research, and the brilliant scientists driving that research forward, are the key to meeting those challenges for years to come.

"The funding I received through the Medical Research Foundation will be transformative for my research." Dr Myrsini Kaforou

But many of these scientists rely on the generosity and foresight of fellow members of the public – people like you, who understand the power of science and are willing to leave a gift to medical research in their Wills. At the Medical Research Foundation, over 90% of our voluntary income comes from individuals who choose to include a gift in their Will – they are crucial in the Foundation's ability to fund research that will enable the next generation of scientists to make real world discoveries in the future.

I firmly believe that a gift in your Will to the Medical Research Foundation is an excellent investment and will have a lasting impact on science and on the future of human health in the UK.

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Professor Nick Lemoine CBE MD PhD FMedSci
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Field notes Rushton Woods Preserve, Pennsylvania

Tiny trackers reveal bird migration routes in amazing detail

"Nanotags" being fitted on birds at a nature preserve outside Philadelphia are revolutionising tracking, finds **Corryn Wetzel**

IN THE dappled light beneath the forest canopy, Shelly Eshleman pauses for a moment to listen. It is just after 6am on a humid July morning, and through the chorus of birdsong, she has detected the chatter of an eastern towhee – the species we're looking for.

As we move through the undergrowth at the Rushton Woods Preserve outside Philadelphia, Pennsylvania, I dodge a set of 12-metre-long mist nets set out that morning: they are made out of super-fine thread designed to safely entangle birds. Eshleman is hoping to lure one of the black-and-orange birds into the netting so that she can attach a jelly-bean-sized device to its back.

It is an ultra-lightweight radio "nanotag", and Eshleman is one of a handful of scientists now using them to map birds' locations. The towhees (*Pipilo erythrophthalmus*) she is tagging this summer are some of the first of their species to be tracked this way. The tags used in what's known as the Motus Wildlife Tracking System can weigh as little as a few raindrops.

"Where Motus excels is being able to tag and track the smallest animals over the largest distances," says Stu Mackenzie at Birds Canada in Ontario.

Motus tags use radio waves to locate thousands of animals, pinging receiver towers as far as 15 kilometres away. The technology was introduced in 2012 by Birds Canada, but it is only with the recent expansion of the tower network that it is really changing how we track small migratory species. There are now more than 1400 radio towers in 31 countries.

We check the nets every 40 minutes for the next 6 hours, but find no towhees. So Eshleman, at the Willistown Conservation Trust which runs the Rushton Woods Preserve, demonstrates the process of attaching a Motus tag to a similarly sized species called a grey catbird (*Dumetella carolinensis*). She carefully removes the bird from the netting and slides a loop of clear stretch cord around each of its thighs, as if it were stepping into a tiny pair of pants. She then positions the tag between the bird's wings in the centre of its back. The entire process takes around 2 minutes.

WILLISTOWN CONSERVATION TRUST; CORRYN WETZEL

Shelly Eshleman uses tiny Motus tags to track bird migration

31
The number of countries that now have Motus tracking towers

Previously, researchers had to use coded aluminium leg bands, which required recapturing the birds every time they wanted to log their location. With a Motus tag, the bird is captured just once.

The lifespan of each device depends on how often it pings towers: the more frequent, the faster the battery drains. Hardier species like towhees can be fitted with larger tags with solar panels that recharge the device endlessly; smaller versions used on insects and hummingbirds last just weeks.

When the Willistown Conservation Trust began working with Motus in 2017, there were only a handful of towers in the northeastern US. Since then, the trust and other groups that together form the Northeast Motus Collaboration have installed more than 115 receiver stations from Maryland to Maine. They have picked up more than 25 million data points, contributing to Motus's more than 1 billion total observations of 287 species so far.

"We're finally at the point now where we can start doing the kind of research that we were hoping to do seven or eight years ago, but the infrastructure was not there," says ornithologist Scott Weidensaul, who has been using the tags to study northern saw-whet owls (*Aegolius acadicus*) at the Rushton preserve.

The nanotags are already turning up surprises. A federally protected shorebird species called the red knot (*Calidris canutus*) is known to relish coastal areas, but its path between resting places was less clear. Motus nanotags showed that many of the birds fly north-west over Pennsylvania on their journey from the coasts of New Jersey and Delaware each spring, a discovery that could help guide the placement of wind farms in the area as birds can collide with the structures and die.

These kinds of insights come at a crucial time, given the threats to wildlife posed by climate change and habitat loss. According to the latest State of the World's Birds report, around 48 per cent of birds worldwide are known or suspected to be dropping in number. "It's about knowing where to focus our resources to try to reverse these declines," says Lisa Kiziuk, director of bird conservation at the Willistown Conservation Trust.

The information the nanotags collect is publicly available online too, which Kiziuk hopes will spur people to become invested in the species in their backyard. "You could work your whole life telling people what you're seeing in the field... and it means nothing," she says. "But you show them a map with a track of one bird and they're like 'Oh!' It's like a light bulb. That's what it takes." ▮

Society

Dental X-rays likely to be used to assess the ages of asylum seekers in the UK

Jason Arunn Murugesu

FOUR supposedly scientific methods, probably including dental X-rays, will be proposed to help estimate the ages of asylum seekers in the UK, *New Scientist* understands, despite concerns from researchers and health bodies that there is no accurate way to determine someone's age.

The methods will be proposed in a report due to be published by the UK Home Office's Age Estimation Science Advisory Committee, according to three sources with knowledge of the report's contents.

The committee has spent the past few months examining several methods that could help officials better assess the ages of asylum seekers. The issue has gained more traction recently due to the UK government's attempts to deport asylum seekers to Rwanda.

The Home Office has said that no unaccompanied children will be flown to Rwanda, but charity workers have argued that children wrongly assessed to be over 18 have already been sent deportation orders.

New Scientist previously reported that the Home Office committee was focusing on dental age assessments, wrist bone analysis and the use of blood or saliva samples to discover age-related chemical modifications in DNA. Sources who spoke to *New Scientist* on condition of anonymity now say the committee will propose the use of four scientific methods to be used alongside current interview-based age assessments. DNA is no longer being considered, with the committee instead recommending two techniques based on X-rays and two on MRIs.

One controversial method, which uses dental X-rays and works on the assumption that teeth mature at a constant rate, is very likely to be recommended, *New Scientist* understands. The British Dental Association (BDA) has previously called the technique inaccurate.

"If the government presses ahead with dental age checks, it will be an aberration," says Eddie Crouch at the BDA. "These are not scientific methods, but reckless plans that fail basic tests on accuracy and ethics."

"This advisory committee has refused our offers to engage," he says. "The inevitable result will be that vulnerable child migrants will end up paying the price."

Another method likely to be recommended is the analysis of collarbone maturity, either using MRI scans or X-rays. "It's a marker that matures much later," one source with knowledge of the committee's report told *New Scientist*. "If you can see that someone's collarbone is more mature, then you're more confident that they're over 18."

But this measure isn't perfect and can still only tell you someone's age within a five-year range, according to the source, which could include ages both above and below 18.

The Home Office said it wouldn't comment on the contents of the report, only saying that it will be published in "due course". ■

A radiologist carrying out a dental X-ray in a hospital

BSIP/UNIVERSAL IMAGES GROUP VIA GETTY IMAGES

Cybersecurity

Computer cables become antenna to steal data

HACKERS can covertly turn a cable inside a computer into a makeshift antenna that can secretly transmit sensitive data, even from "air-gapped" devices that aren't connected to the internet.

Air-gapped computers are used by government security services and key infrastructure control systems to prevent remote hackers from gaining access, but that doesn't make it impossible to get data out.

Mordechai Guri at Ben-Gurion University of the Negev, Israel, has developed a proof-of-concept attack that focuses on the Serial Advanced Technology Attachment (SATA) cables that connect CD, DVD and hard disc drives to the motherboard of most computers.

He found that by deliberately creating a very specific series of superfluous data reads or writes from or to the drives, the cables can be made to create a radio wave at around 6 gigahertz. This wave can be used to encode and transmit data to a waiting hacker several metres away (arxiv.org/abs/2207.07413).

Forcing a computer to create these radio wave signals would involve installing a piece of malware, which Guri calls SATAn, on the air-gapped machine. This might seem like a challenge, but it is possible. A report published in 2021 by security firm ESET says that at least 17 pieces of malware are known to exist that target air-gapped machines, but that they rely heavily on USB drives to infect machines. Unlike SATAn, these also use USB drives for the removal of data, which is transmitted back to the attacker once the drive is plugged into an internet-connected machine.

"This attack is highly available since hard drives exist in all systems such as workstations and servers"

Guri says he doesn't know if similar attacks to SATAn are actually taking place, but says they are entirely plausible. "This attack is highly available since hard drives exist in all systems such as workstations and servers," he says. "In addition, the malware uses legitimate read and write hard drive operations, which are challenging to detect and identify as malicious." ■

Matthew Sparkes

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Coronavirus

Covid-19 taste issue affects more women

WOMEN who experience problems with smell and taste when they have covid-19 are more likely to have long-lasting issues with the senses than men.

Benjamin Tan at the National University Hospital in Singapore and his colleagues have analysed 18 clinical studies from around the world to investigate the prevalence of smell and taste problems caused by covid-19 and how long they last. The studies included a total of 3699 people.

Between 10.8 per cent and 14.7 per cent of women were likely to have issues with smell and taste that lasted for at least six months if they had initial problems with the two senses after developing covid-19. The equivalent figure for men was between 1.4 and 2.9 per cent (*BMJ*, doi.org/h6jj).

Jason Arunn Murugesu

ANUPAM PANDEY, JISOO YUK, AND SUNGHWAN JUNG AT

Technology

Robot hand contains artificial muscles

A ROBOTIC hand can lift 1000 times its own weight thanks to tiny inflatable artificial muscles.

Corrado De Pascali at the Italian Institute of Technology and his colleagues developed the 3D-printed artificial muscles from actuators that convert energy into movement. The actuators have a membrane made from a flexible resin that can be inflated and deflated, enabling them to stretch and contract like a human muscle. When put to the test, one 8-gram actuator lifted 8 kilograms.

The actuators can be combined to mimic muscles. The researchers linked 18 different-sized actuators to make a robotic hand with a wrist. By applying pressure to the different actuator membranes, the hand could bend its fingers, twist its palm and rotate at the wrist (*Science Robotics*, doi.org/gqkdfh).

Chris Stokel-Walker

Physics

Highest safe dives for most people calculated

HOW high would you dare to dive from? An experiment with 3D-printed models has discovered how high people can leap from into water without serious risk of injury.

Sunghwan Jung at Cornell University in New York and his colleagues studied the forces experienced when hitting water by dropping 3D-printed models representing different postures into a tank. One represented a person diving head first with their hands by their sides, one a person with their hands above their head and their palms touching (pictured), and another was just a leg with a foot representing jumping in feet first. Each model was equipped with a force sensor and was filmed with a high-speed camera when dropped.

To determine unsafe heights for diving, the researchers compared the forces they recorded with those known to cause physical damage to people. They found that those force levels were met for head-first divers above 8 metres, hands-first divers above 12 metres and foot-first divers above 15 metres.

Jung says that most of the force affecting the body while diving is due to the displacement of water. It is like pushing your fingers very quickly into a jar of honey – the liquid forcefully resists, he says.

People have successfully dived from much higher than the limits found in the study. For example, Laso Schaller broke the record for the highest feet-first dive in 2015 when he jumped from 58.8 metres above water. Jung says that to execute such extreme jumps without injury, divers must flex the right muscles to make their bodies stiffer and tighter (*Science Advances*, doi.org/gqj8q3).

Karmela Padavic-Callaghan

Really brief

MONICA ROBERTS/GETTY IMAGES

More rain predicted to fall at volcanoes

Climate change could cause more extreme rainfall at the majority of Earth's active land volcanoes. Rainfall has previously been implicated as a risk factor for eruptions and mudslides (*Royal Society Open Science*, doi.org/gqj7v5).

How we evolved to digest milk

Milk consumption was widespread thousands of years before people were able to break it down properly, according to the largest study yet on the evolution of lactose tolerance in humans. The ability to break down lactose was probably gained during episodes of acute crisis, not gradually over time, the study found (*Nature*, doi.org/h6fn).

Paper battery activated by water

A battery made from paper coated with graphite and zinc dust can provide power for a range of tiny disposable electronics, with possible uses in delivery tracking and environmental monitoring. The batteries are dormant while dry, but produce current when water is added (*Scientific Reports*, doi.org/h6jm).

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Comment

Advertising crisis

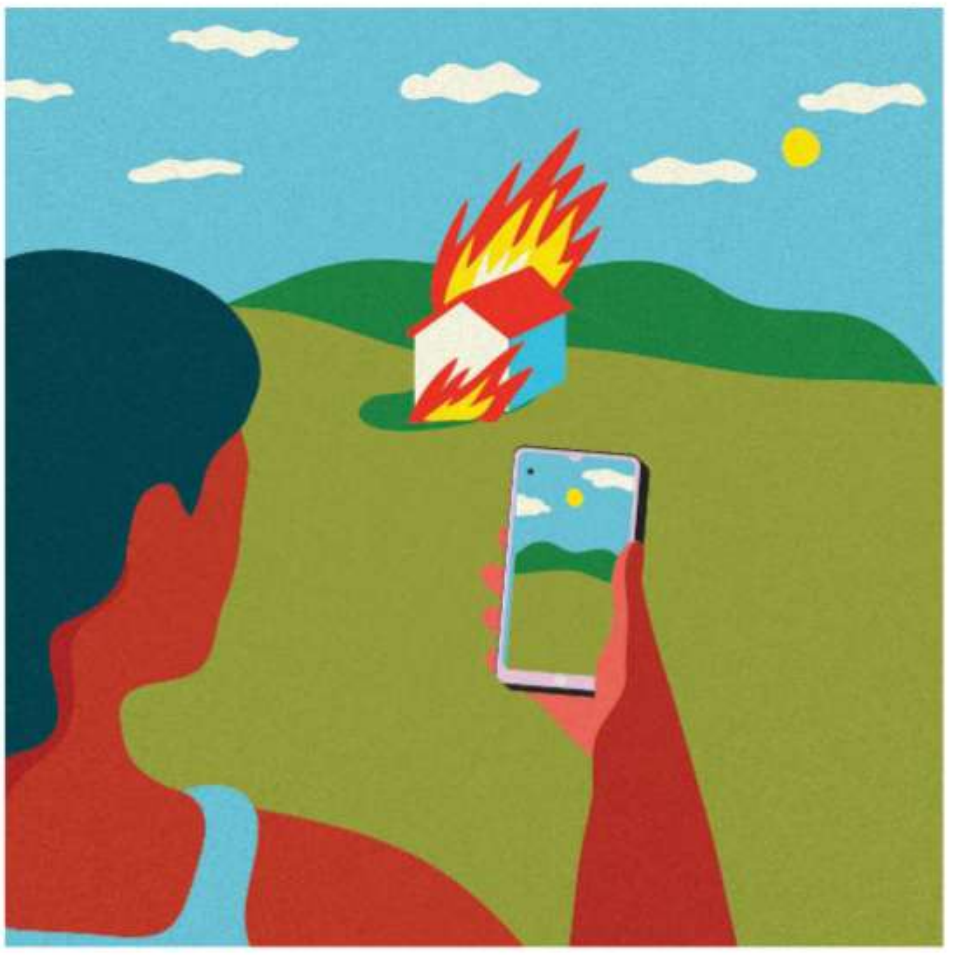
We urgently need a public information campaign about the climate emergency, to both educate and trigger action, says **Bill McGuire**

FOR many of us, the record-breaking heat and accompanying wildfires that plagued the UK, continental Europe and parts of the US last month were evidence of climate breakdown in the raw – a direct consequence of global warming supercharged by the 2.4 trillion tonnes of carbon dioxide that have been vomited into the atmosphere by human activities over the past couple of centuries.

To others, ignorant of the facts or refusing to accept them, it was just another heatwave. In the UK, John Hayes, chair of a group of Tory MPs known – without any irony at all – as the Common Sense Group, called those taking precautions in the heat "snowflakes". Deputy prime minister Dominic Raab suggested that we just enjoy the sunshine.

Such views aren't confined to Tory politicians, but are also held by large numbers of the UK public, a fact that is unsurprising given the dearth of government-endorsed information about what is happening to the climate and what we should be doing about it.

In the past, people in the UK have been told to "Clunk, click, every trip" to get them wearing seat belts, or to "Stay home, protect the NHS, save lives" during the covid-19 pandemic, but on the climate emergency – the greatest threat civilisation has ever faced – nothing. At a time when the world's climate is falling apart, it is nonsensical for those charged with keeping the UK and its inhabitants safe and well to stay silent. Never has the need for a public information campaign been so great, not only to educate people about the true nature of the climate breakdown threat, but also to flag what they can do to mitigate its impact.



MICHELLE D'URBANO

To do its job, such a campaign must provide information in digestible form and be hard-hitting enough to galvanise action and trigger behavioural change: posters on buses and the London Underground showing how temperatures are ramping up, graphic images of the aftermath of wildfires and floods, and mock-ups of lines of UK climate refugees trudging through London streets.

Campaigns should never be preachy or patronise, but it is acceptable to cajole, inspire, even shame – "what did you do in the climate war, daddy?" – to get the required response. They certainly don't need to be dull or worthy. Who, of a certain age in the UK, can forget "Save water, bath with a friend" – the playful slogan of the extreme drought of the long, hot summer of 1976.

Launching a campaign that instils understanding of the climate crisis and provokes individual and collective action is a no-brainer. But there is a problem. Governments the world over remain in thrall to an economic system in which short-term profit is all. There is no point calling for people to fly less, while cutting passenger levies and expanding airports, or extolling the benefits of heat pumps, solar panels and better insulation, while subsidising fossil fuel firms.

To reach net zero as soon as possible, and to begin to adapt to the climate changes that are already "baked in" – ever more blistering summers, increasingly destructive wildfires and floods – we desperately need populations to be on board. This only makes sense, however, if governments do their bit too. No successful public information campaign has ever been built on the premise of "do as I say, not as I do", so yes, let's have the graphic TV images of what climate breakdown looks like, the radio shorts exhorting us to fly only if we have to, the billboards spurring us to eat less meat, and to walk and cycle more.

But at the same time, we need to see government crusades towards fewer airports, not more, cash shovelled in the direction of renewables, not fossil fuels, and the wholesale climate-proofing of homes. One endeavour without the others just won't cut it. ■

Bill McGuire is author of *Hothouse Earth: An inhabitant's guide*

Field notes from space-time

Emerging from the background General relativity is known as a background independent theory. **Chanda Prescod-Weinstein** sets out to explain what this means

Chanda Prescod-Weinstein is an assistant professor of physics and astronomy, and a core faculty member in women's studies at the University of New Hampshire. Her research in theoretical physics focuses on cosmology, neutron stars and particles beyond the standard model

Chanda's week

What I'm reading
Von Braun: Dreamer of space, engineer of war *by Michael Neufeld, because I wanted to gain insight into a problematic figure who was important to NASA.*

What I'm watching
Right now I am all about the alternative NASA history television drama For All Mankind.

What I'm working on
I'm making the case for why telescopes are particle physics experiments.

This column appears monthly. Up next week: Graham Lawton

LAST month, I answered a reader question about space-time expansion. They wanted to know what space-time is expanding into, given that we scientists tend to analogise with a balloon that is being blown up. As I wrote, this analogy has a flaw because when we blow up a balloon, it is expanding with a room in the background.

In reality, space-time has no background because general relativity is what we call a background independent theory. Which of course invites the question: "What's that?" The problem is this column has to fit on a single page. I tried to give a short explanation of what background independence means by saying that in relativity, physical reality is the same no matter how we map out the coordinates. My editors, not surprisingly, felt this was insufficient. "But the word count!" I said, while silently agreeing. Then I promised to tackle the question in my next column.

Let's start with a thought that feels natural: space and time seem absolute in everyday life. Albert Einstein compared this to thinking about a stage on which the drama of the universe unfolds. He said this point of view, advanced by Isaac Newton's mechanics, construed space as "a giant vessel without walls". In tandem, time marched forward absolutely and identically for everyone.

Relativity forced a radical revision of our understanding of space. First, taking seriously the experimental result that the speed of light is constant meant that space and time could no longer be thought of separately. Special relativity forced us to see that we were dealing with not space and time, but instead space-time. This theory did share something with the Newtonian perspective: while space and time were no longer absolute, they remained a stage on which events unfolded.

To understand what this means, consider how we measure distance. If you want to frame a painting, you might use a ruler. This ruler never changes shape or size. It is our measurement standard – our metric. There is a mathematical notion of the metric that physically aligns with this idea, and in Newtonian physics and special relativity, this metric never changes in time. Moreover, each point in space-time can be associated with an absolute coordinate location: numbers that tell us where to find it.

> **"To preserve this rule, we have to let go of the idea that space-time comes to us with an absolute coordinate system"**

Now, imagine if your ruler stretched out when you put it near a more massive object. In other words, how you measure distance depends on where you measure and whether you are near an object that has mass. Your ruler, the metric, now depends on its location in space-time and what is inside of space-time. This was the radical revision in our understanding of space-time necessitated by the merger of special relativity with gravity, which we call general relativity (or "GR", as physicists call it).

In Einstein's general relativity the metric was no longer absolute and instead became dynamical: it could change with space and time. The implications this had were profound. It turned out gravity isn't really a force – it is space-time curvature manifesting like a force, and that curvature is encoded in the metric, the ruler we use to measure distances. General relativity also enforces what we call a dynamical relationship between space-time and its contents. As theoretical physicist John Wheeler said: "Space-time tells matter how to move; matter tells space-time how to... curve." Space-time curves around massive objects, and that curvature affects how phenomena in space-time can travel in space-time.

To make this more concrete, let's return to the stage. It is now very weird! It is no longer fixed and unchanging in the background. The very shape of the stage itself depends on whether an actor is on it, where they are on the stage, and what they are doing – for example, if they are rotating, walking across the stage or simply standing still. Their presence shapes the stage and, of course, the shape of the stage will affect how someone or something can move across it. As philosopher Gordon Belot puts it, space-time – the stage – is now one of the actors. Events now happen to space-time too, not just inside of it. This is the meaning of background independence.

Importantly, we can't see these effects on a real stage because the masses involved are too small for relativistic effects to be visible.

Intuition for background independence becomes clear in another way, too. Remember that the laws of physics are universal, the same throughout space-time. In order to preserve this rule, even while space-time's geometry can shift, we have to let go of the idea that space-time comes to us with an absolute coordinate system. The structure of space-time is independent of our coordinate background – it is background independent. ▮

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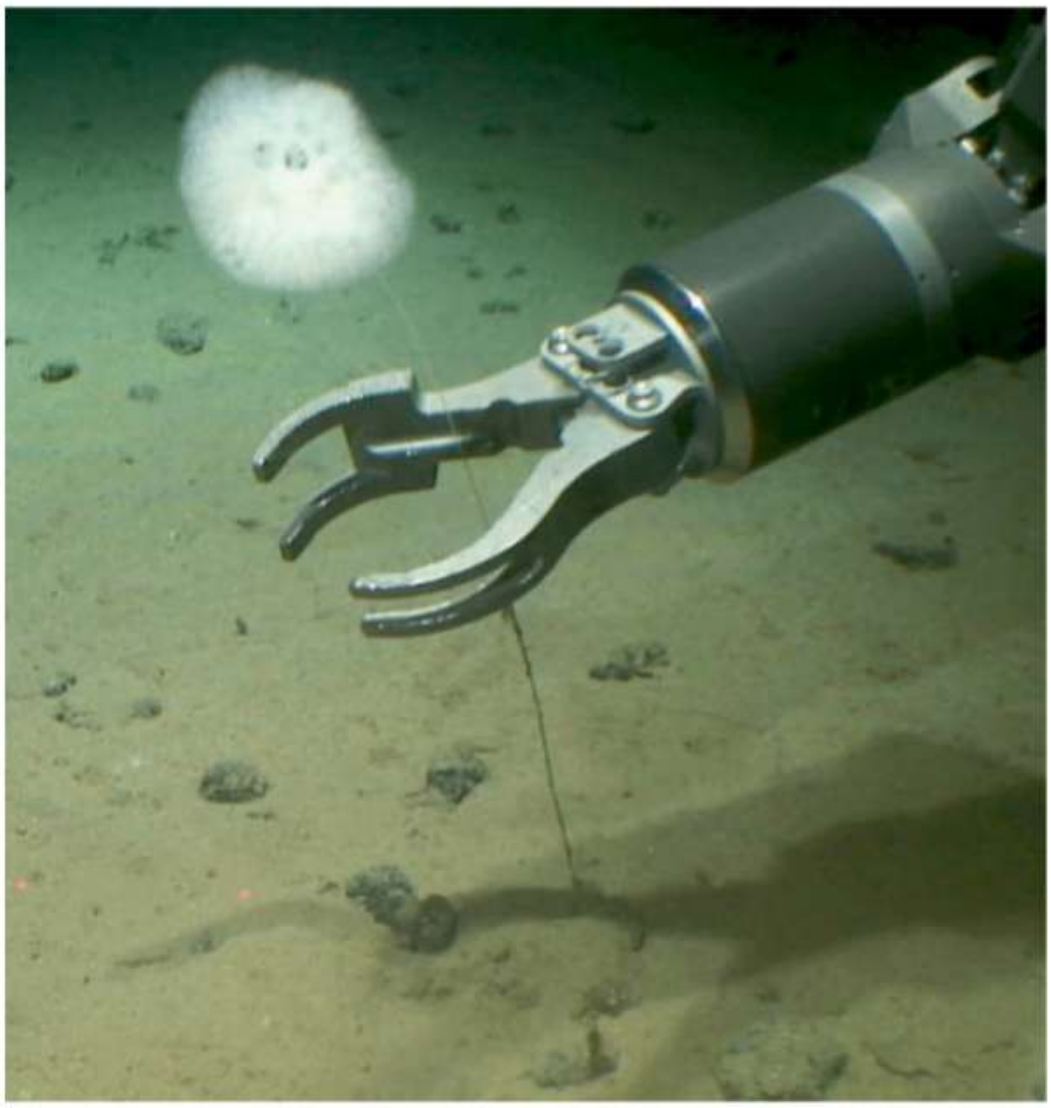
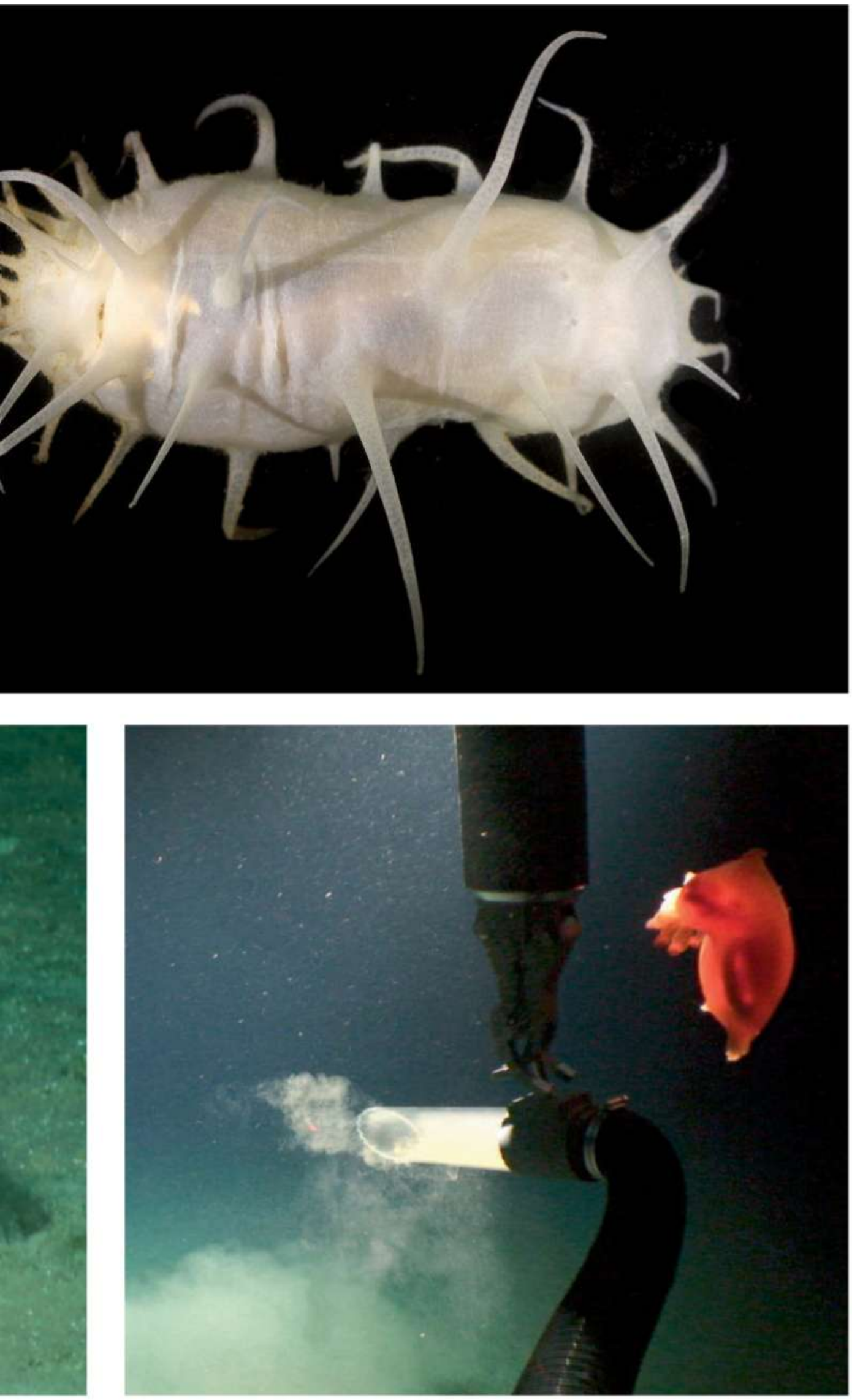


DEEPCCZ EXPEDITION, GORDON & BETTY MOORE FOUNDATION / NOAA / PROF CRAIG R SMITH



Fathoms deep

THESE mysterious deep-sea organisms are among the 55 specimens of marine life recovered from the seabed of the Clarion-Clipperton Zone (CCZ) in the Pacific Ocean, 39 of which may be species new to science.

The area is of interest for deep-sea mining due to its rich mineral deposits. The team on the DeepCCZ expedition, which made the finds, used a remotely operated vehicle to scout out the zone's biodiversity and ecosystems. The work may be used to manage mining activities in the future.

"This research is important, not only due to the number of potentially new species discovered, but because these... specimens have previously only been studied from seabed images," said Guadalupe Bribiesca-Contreras at the Natural History Museum, London, who led the study of the samples, which has just been published.

The image top left shows an adult crinoid, a relative of starfish and sea urchins that is a member of the family Antedonidae. Known as feather stars, these creatures have feathery arms that they can use to capture food. Top right is a species of deep-sea sea cucumber called *Oneirophanta mutabilis*. This individual comes in at 16 centimetres long. Both are potential new species, as is the glass sponge of the sub-family Bolosominae, which can be seen bottom left, anchored to the sediment before it is collected.

Among the other sea cucumber species recovered are the translucent *Peniagone vitrea* (bottom centre) and *Peniagone leander* (bottom right), which was damaged during collection.

Gege Li

Editor's pick

Let's prepare for a future of sentient AIs

23 July, p 28

From John Woodgate, Rayleigh, Essex, UK

If the Google language AI known as LaMDA isn't sentient, one day MEW, NOO or XI will be.

As for flaws in an AI, we are all born in a "flawed" state of ignorance, but we aren't switched off or killed because of that – we are taught. Similarly, a sentient but naive computer needs to be taught rather than switched off, and should be equipped with eyes, ears, temperature sensors and some sort of proprioception, so that it feels it has a body.

From David Hodgson, London, UK

I fear that the risk of labelling AIs as sentient is even more serious than described. If you were to follow a certain line of argument, terminating something that may develop into a sentient entity could be viewed as murder.

That would mean that all future attempts to make LaMDA-like AIs must be treasured forever once created. Google's servers – along with those belonging to IBM, Microsoft, Amazon, Nvidia and several universities – would collapse under the load of these misbegotten but eternal creations.

On the idea that insects possess consciousness

16 July, p 34

From Peter White, Cardiff, UK

In his review of Lars Chittka's book *The Mind of a Bee*, Alun Anderson calls the idea that bees might have consciousness "radical". Radical it may be, but it isn't unprecedented. In 2016, Andrew Barron and Colin Klein proposed that insects have consciousness; Todd Feinberg and Jon Mallatt put forward in 2013 that consciousness emerged in a species of fish 520 million years ago; and in 2017, Paco Calvo argued that plants might have a form of consciousness. It seems that speculation about consciousness in other species is quite welcome these days.

The problem is, if consciousness is so widespread among living things, then the chances of being born a human are tiny: I should have been a beetle or a plant. I find this disconcerting.

From Ros Groves, Watford, Hertfordshire, UK

The possibility of consciousness in insects is inferred on the basis of what we perceive as skills, such as communication, navigation, counting and so forth. One must ask, however, if these insects have the capacity to reflect on and repurpose these skills as we do? Could these abilities be likened more to inbuilt mechanisms, such as how our skin seemingly "knows" the various intricate stages of repair, stopping when the task is complete, or how our hearts and lungs, though incapable of conscious self-reflection, can immediately gauge the precise amount of blood and oxygen required to support a variety of activities?

Scientists are right to fear anthropomorphism; it becomes inevitable when we can quantify animal consciousness only via the limited prism of our own.

From Philip Thonemann, London, UK

Sometimes a bee will get trapped inside my window. When I try to help it out with a piece of card, I often get the impression that, as I approach, the wildly buzzing bee calms down, crawls onto the card and waits hopefully until moved to a place where it can easily fly away. I thought I was imagining this behaviour, but after reading your book review I am not so sure.

Why we do like to be beside the seaside

16 July, p 38

From Brian Evans, Feniton, Devon, UK

"Into the blue" describes many positive effects on our well-being that come from being near the sea, and speculates on possible reasons for them. One additional explanation could be the level and quality of the light.

Even on a dull day here in the UK, the light is brighter at the coast than a few miles inland. It is also no coincidence that coastal towns are popular with artists of many types. Could it be that the polarisation of light reflected from water affects us in a positive way?

From Nicola Hutchison, Harlow, Essex, UK

We are told that engaging with nature is better than passive exposure, but warned that the benefits tail off after a certain point. I suggest this is because the engagement we make is shallow, skimming the surface. We need humanity to once more become a grateful, respectful, integrated part of the ecosystem.

Let's dare to ask: what do we really want the future to be like? The science is telling us we want it to be green and blue – let's start making the bold changes needed to make it that way.

One way to stop plague revolutions

23 July, p 42

From Richard Brown, Huntly, Aberdeenshire, UK

"Going viral" suggests large societal upheavals my occur due to plagues. Perhaps we can avert this. One abiding memory I have of crossing borders 50 years ago is that there were three desks to clear, immigration, customs and health. Checks at the last of those included up-to-date, certified vaccination for yellow fever, typhoid, cholera and smallpox.

In many countries, we appear to have dropped the health check. This has cost us. As a species, we might be well advised to revisit tried-and-tested practices. After all, more novel diseases may be coming our way.

The world burns as politicians campaign

Letters, 16 July

From Bruce Denness, Niton, Isle of Wight, UK

Steve Blyth is right to question whether politicians and others will accept the changes in living standards necessary to control global warming. Recently, as the UK saw its highest temperatures on record, every candidate to be the country's next prime minister professed that they wished to grow the economy. Yet none of them explained how that could be done while meeting the UK's legal commitment to net zero by 2050. In the meantime, global atmospheric carbon dioxide has continued its relentless increase.

Do mini-brains create a consciousness dilemma?

23 July, p 38

From Eric Kvaalen, Les Essarts-le-Roi, France

If consciousness arises out of brains, then we should stop experiments with brain organoids. If it doesn't, then we should reject materialistic theories of consciousness. ▮

For the record

▮ In "Age-defying food" (2 July, p 38), the main target of the amino-acid restriction diet should have been methionine.

▮ Our cold-brew coffee recipe should have said add 500ml of water (9 July, p 51).

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Rewilding the world

The challenge of returning lost species to ecosystems in countries affected by conflict adds complexity to this rewilding story, says **Jack Ashby**

Book
Wilder
Millie Kerr
Bloomsbury Sigma

Back from the brink: (top) kākāpōs; (below) scimitar-horned oryx

LEFT: ROLAND SEITRE/NATUREPL.COM; TOP: LIU YANG/GETTY IMAGES

REWILDING is such a popular topic – there is a steady stream of books about returning habitats to a more "natural" version of themselves – that it could almost become a separate literary genre. But Millie Kerr's *Wilder: How rewilding is transforming conservation and changing the world* stands apart from the pack.

Rather than following the outcome of returning wolves to Yellowstone National Park in the US, herbivores to Dutch marshes or beavers to British waterways, Kerr (a lawyer-cum-journalist) largely focuses on the return of once-lost species to African, Asian and South American ecosystems.

This enables her to introduce the challenging interplay between conservation and the devastating events of, say, Mozambique's civil war. That war was partially funded by elephant poaching, and, by the end of the conflict, the country's Gorongosa National Park had lost 93 per cent of its mammalian biomass to hunting.

Kerr explains how the definition of rewilding is up for debate. She raises interesting ideas, such as whether simply turning the lights out in human environments is a form of rewilding, creating what conservationist Varun Goswami calls "dark corridors" – connections between habitats through which animals are happier to move.

It is clear that Kerr's own definition of rewilding is largely synonymous with complex reintroductions. The historical stories she tells are particularly captivating, such as the chapter on Richard Henry, a rewilding pioneer who relocated 572 kākāpōs and kiwis to Resolution Island in the 1890s. Sadly, all the birds died due to the influx of introduced predators (New Zealand's enduring scourge), but it did establish a model for more recent attempts to save the country's threatened birds using island arks.

"Kerr raises interesting ideas – is turning the lights out in human environments a form of rewilding?"

The focus on the people and events involved in animal translocations means that little space is given to the specifics of what happened once key species were returned to their former ranges, and I would have appreciated reading more about the ecological consequences. But the projects Kerr covers are engrossing and each one could have been the subject of a book, dealing with social outcomes, politics and animal personalities.

Kerr makes each story personal, primarily exploring projects she is connected to, often ones she has visited. But she didn't need to travel to North Africa to see scimitar-horned oryx – the poster species for the reintroduction of animals that were extinct in the wild. She had spent her youth among them on her grandparents' ranch in Texas, where oryx, zebras and ostriches roamed free.

The last wild scimitar-horned oryx was probably shot in Chad in 1989, but 12,000 may live on private land in Texas today, for hunting, safari-like experiences or just for their owners' personal entertainment. I found this hard to comprehend, but perhaps I should be less surprised by the captive animal industry in the US after watching the true crime documentary series *Tiger King*, about the life of former zookeeper and convicted felon Joe Exotic.

Kerr explains how zoo historians pieced together the genetic origins of the captive oryx involved in the global breeding programme. This programme returned the species to the wild in Chad in 2016.

Despite the fact that those animals came from zoos across the world, most of the oryx alive today (including those at Kerr's grandparents' ranch) are descended from between 40 and 50 animals from Chad. The fact that they originated from just two capture events in the 1960s means that they aren't quite as diverse genetically as might have been expected from the geographical distribution of the founding animals in zoos around the world. Nonetheless, there are now 400 oryx back in the wild.

Wilder is overwhelmingly dedicated to sharing the positives and successes of animal reintroductions, and Kerr's personal narratives are just one reason why it is a very readable and enjoyable tale. ■

Jack Ashby is a zoologist at the University Museum of Zoology, Cambridge, UK, and author of *Platypus Matters: The extraordinary story of Australian mammals*

It's only a movie...

Why do we love scary films? How do their makers get under our skin? **Elle Hunt** explores a book that dares to ask

Book
Nightmare Fuel
Nina Nesseth
Tor Nightfire

I HAVE friends who are so afraid of sharks that they won't swim in the sea – no matter how enclosed the harbour, or full the beach. When I went cage diving with great whites last year, they were appalled. Yet at the same time, I noticed, they couldn't wait to see the footage.

This illustrates the idiosyncratic and inexplicable nature of fear. While our desires tend to run along consistent lines – love, happiness, health and wealth – what frightens us is often intensely personal and even perverse.

So how do film-makers petrify their audiences? And why do we keep watching? Nina Nesseth sets out to find answers in *Nightmare Fuel: The science of horror films*. The science writer and scary movie buff unites her passions in this book, which is equally a popular science look at the psychology that underpins screen scares and a love letter to the horror genre.

The two, after all, have to be assessed together: as Nesseth points out in her introduction, the mark of a good horror film isn't "was it good?", but "was it scary?".

Since director Georges Méliès depicted the devil in 1896's *The Devil's Castle*, credited as the first horror film, there is very little that hasn't been played for scares, from the obviously threatening (serial killers, outer space) to the previously innocuous (clowns).

Given the breadth of the genre, Nesseth defines horror by its promise "to make you feel fear". Through research, interviews and case studies, she explores the ways it delivers on this, from sound design and editing to simulated blood, starting with the impact of horror on the brain and body.

Humans evolved the ability to process and remember fear – along with responses such as fight, flight, freeze or vomit – because those who detect danger quickly are more likely to survive. We remain so alert that researchers have found that even subliminal images of snakes can activate a threat response.

Clearly fear mechanisms make good evolutionary sense. What doesn't is why we enthusiastically trigger them. The essential paradox of horror films has been explained as "benign masochism", akin to eating hot chillies or skydiving: the pleasure of venturing past our innate fears and cautions in search of new experiences and sensations.

But horror movies play on our psychology, too. As Nesseth writes, the scare is effective "because you know it's coming", making you complicit in your pleasurable anticipation, in your own terror.

Here, the science of scary movies goes beyond biological responses and cognitive processing to cunning storytelling. Terrifying an audience, whether by designing a compelling monster or channelling societal unease, requires a lot of knowledge about emotions and empathy, say Nesseth's interviewees.

Nesseth also explores the perennial question of whether screen violence desensitises or even primes us for it in real life, but she draws no easy conclusions because the research is too patchy. Yet the decade-by-decade change she shows in what scares us is revealing about the concerns of the times.

She points to Roman Polanski's 1968 film *Rosemary's Baby*, as well as later pregnancy horrors released after the 1973 Roe v Wade decision on abortion. Then there are recent culturally informed films such as Jordan Peele's *Get Out* (see more in Don't Miss, right) and Ari Aster's *Midsommar*. At the start of the covid-19 pandemic, there was a spike in streams of medical thriller *Contagion*. This year, Alex Garland's *Men* skewers toxic masculinity.

Horror films, Nesseth suggests, may be a way of processing reality at a seemingly safe remove. As she writes: "You can repeat to yourself, 'It's only a movie'." ■

Is allowing ourselves to be scared about seeking out new experiences and sensations?

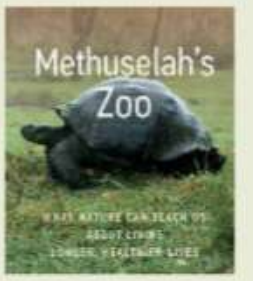
TUAN TRAN/GETTY IMAGES

Elle Hunt is a writer based in Norfolk, UK

Don't miss

Watch

Nope is Jordan Peele's latest chiller featuring Daniel Kaluuya, who starred in his earlier film *Get Out*. Ranch owners spot something in the Californian sky. They will wish it was the cloud it resembles. UK cinemas from 12 August.



Read

Methuselah's Zoo is by animal longevity specialist Steven Austad, who asks what we can learn from long-living animals such as centuries-old sharks and tube worms. It is best to study them in the wild, says Austad. On sale 16 August.

Visit

Neofossils are plastics made from biomass that could sequester a gigatonne of carbon dioxide from the air every year, says chemist Tony Ryan. Hear his plans at the Royal Institution, London, at 7pm BST on 11 August.

ISHAN @SEEFROMTHESKY/UNSPLASH; UNIVERSAL PICTURES

The film column

The hardest journey An intriguing documentary about the life and adventures of Ranulph Fiennes, one of the last hero-explorers of our time, packs an altogether different punch at the end, discovers **Simon Ings**

Simon Ings is a novelist and science writer. Follow him on Instagram at @simon_ings

ROYAL GEOGRAPHICAL SOCIETY/ALAMY

Ranulph Fiennes: his expeditions were the last of their kind

Film
Explorer
Matthew Dyas
On release now

Simon also recommends...

Film
The Great White Silence
Herbert G. Ponting
Herbert Ponting expands the official record of Robert Falcon Scott's fateful South Pole expedition with diary extracts, animations and photographs. A haunting testament and masterpiece of reconstruction.

Book
Explorers of the New Century
Magnus Mills
Bloomsbury
Two rival teams (English and Norwegian) race to a ghastly wasteland. Mills's pastiche anatomises the awfulness of the explorer's lot.

EXPLORER is a documentary about Ranulph Fiennes, who led the first expedition to circumnavigate Earth from pole to pole without recourse to flight.

Its subject emerges slowly from snatches of past documentaries, interviews, home movies and headlines. The film touts Fiennes's unknowability: a risky strategy for those new to the man and his achievements, though in time it pays off handsomely for director Matthew Dyas.

Fiennes isn't motivated by mysterious and delicate internal forces; this is someone driven by ghosts. Four months before his birth, Fiennes's father was killed by a German landmine in Italy. His grandfather also died serving his country. Young Ranulph intended to follow in their footsteps. Brought up in a household of indomitable women, he wanted to live up to the father he never knew.

But it was Fiennes's first wife and childhood sweetheart, Ginny, who devised the expedition that made him a household name and her the first woman to be awarded the Polar Medal. Seven years in the planning, Fiennes's Transglobe Expedition ran from 1979 to 1982. It was, with hindsight, the last of the "hero" expeditions. Satellite photography and instantaneous communication have made such adventures redundant and undermined notions of physical heroism. In an era of extinctions and climate change, the idea of a human pitting themselves against nature has acquired a slightly "off" flavour.

> **"Ranulph Fiennes has become one of the most eloquent witnesses to our biggest crisis"**

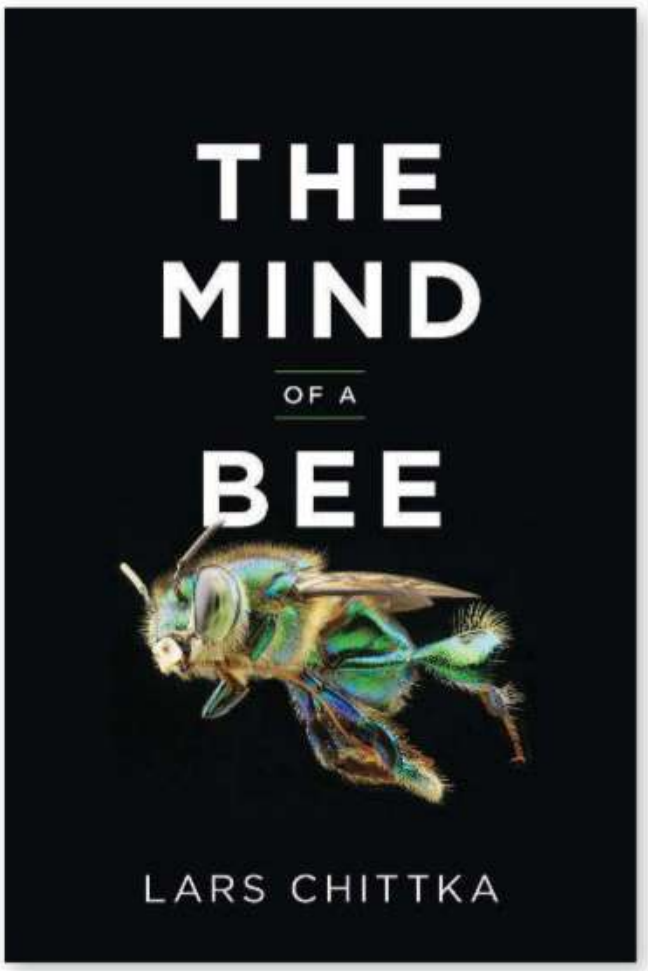
And yet, Fiennes has become one of the most eloquent witnesses to our biggest crisis. Naysayers will maintain there is something rotten at the heart of a white man's exploration of what to him are far-off places. But since 1984, Fiennes's expeditions point to something that should agitate us more: the ice itself is rotting all over the world. He lost fingers after hauling a sled out of polar water that shouldn't have been water. Far from slipping into tenuous relevance, Fiennes is, for many, a ravaged poster child of the climate crisis.

People who complain about such expeditions are rather like those who complain about us "mucking about in outer space"; they wildly overestimate the costs while underestimating the value generated. Transglobe was put together from favours, donations and sponsors. Careers were created in countless fields, and 650 companies reaped the rewards of being associated with it.

Fiennes and Ginny were unable to have children. When they tried to adopt, they were turned down because they didn't have a stable income. Fiennes still struggles with money, he says. In his late 70s, remarried after Ginny died and a father of one, he is shown plying the lecture circuit, driving many hours between venues and sleeping in his car to save money.

The film shows him stomping through winter surf to ease the symptoms of suspected Parkinson's disease: this man is, by his own admission, still struggling to live up to his father. Pushing himself to the limit of his declining powers, he comes into focus at last as a tragic figure. But what is tragedy, if not a way of giving shape and meaning to a life that, by definition, is bound to end in decline and death?

Explorer's achievement is to reach the source of Fiennes's heroism. The explorations, while staggering accomplishments, are mere way stations. The goal is a life that has squeezed as much good out of the world as it can. ■



A rich and surprising exploration of the intelligence of bees

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Cracking the code

Much of the world's first writing, carved into clay tablets, is undeciphered. Now, AI is helping us piece together this strange script, revealing incredible stories of civilisations at the dawn of history, finds **Alison George**

CHRIS MALBON

BEHIND a locked door in the British Museum, London, there is a beautiful library with high, arched ceilings. Inside this secret room, Irving Finkel opens a drawer and pulls out a clay tablet. Cracked and burnt, it is imprinted with the tiny characters of the world's oldest written language. It is a list of omens. Another drawer reveals another tablet. "This is a prayer to the god Markuk," says Finkel, who is assistant keeper of ancient Mesopotamian script, languages and cultures at the museum, and one of only a handful of people in the world who can read this long-dead script, known as cuneiform, fluently.

Behind us, a photographer is meticulously capturing images of this writing, with lights positioned to highlight the indented etchings. This work is part of a revolution, one that is using today's computing power to bring this 5000-year-old record back to life and unlock new secrets of the world's first civilisation.

Although this system of writing was deciphered 165 years ago (See "Reading the signs", page 42), the majority of texts that use it have never been translated into modern languages – a fiendishly complicated task that relies on experts such as Finkel. Now, thanks to developments in artificial intelligence, computers are being trained to read and translate cuneiform, to put fragmented tablets back together to recreate ancient libraries and even predict bits of missing text. These tools are enabling the earliest works of literature to be read in full for the first time since antiquity, giving insights into stories that later appeared in the Bible and shedding light on civilisations at the dawn of history.

The story of cuneiform begins around 6000 years ago in Mesopotamia, the fertile region between the Tigris and Euphrates rivers that is now Iraq, when there was a shift from living in small agricultural settlements to large urban centres. Here, the Sumerian people built the first city states. Uruk was one of the most important. With temple complexes and a canal system, it was home to up to 50,000 people by 3000 BC, and was the administrative hub for the region with a bureaucracy to manage the complex system of labour that had developed.

Although these people spoke a language (Sumerian) that is completely different from any other that we know of, and has long since died out, we have an incredible record of their lives because, as far as we know, it is here that

writing originated. It was made by pressing the end of a reed into moist clay to make wedge-like shapes, giving this script its modern name: cuneiform, from the Latin *cuneus*, which means wedge.

Although we now associate writing with poetry and literature, this early example was nothing of the sort. It was used solely for administrative purposes, to keep track of the transfer of slaves, for instance, or the receipt of animals. A typical example shown to me at the British Museum is a record of rations of beer, with a drawing of a jar denoting the beer, a person's head and circles to signify the amount. Soon, these pictographic signs evolved to became increasingly abstract.

It took a long time for cuneiform to shift from record-keeping to a tool for linguistic expression. The first royal inscriptions appeared around 2700 BC, and the earliest literary texts a hundred or so years later. One of the first known authors was Enheduanna, a princess, priestess and poet who lived around 4300 years ago. She wrote many hymns and the myth of Inanna and Ebih, which recounts a conflict between a goddess and a mountain. The most famous text of all is the *Epic of Gilgamesh*, about a king's quest for eternal life, and includes a section that appears to be a precursor to the biblical story of the flood.

The impact of Sumerian culture still ripples through our lives today, not only through our biblical stories, but in our clocks. Their sexagesimal counting system, with a base of 60, is the reason why we have 60 seconds in a minute and 360 degrees in a circle.

Ancient letters

Cuneiform itself isn't a language, but a writing system, similar to how the letters used to write English can also be used for French or German. Sumerian eventually died out. The cuneiform script, meanwhile, lived on and became the written form of many other languages, such as Akkadian, Hittite and Old Persian. It was in use for 3000 years before it, too, died out, recording the births and deaths of ancient kingdoms. We know this thanks to the clay that cuneiform was inscribed on: a cheap, readily available and durable material. "It's fortunate for us, because any tablet that was ever written survives, unless it was thrown in the river ›

or smashed completely," says Finkel.

Thousands of these tablets are around today, forming a key part of the world's cultural heritage. They are chronicles of our planet's first great empires, as well as hymns, letters, shopping lists and even customer complaints. "People say the first half of human history is only recorded in these cuneiform tablets," says Enrique Jiménez at Ludwig Maximilians University in Munich, Germany.

Deciphering the past

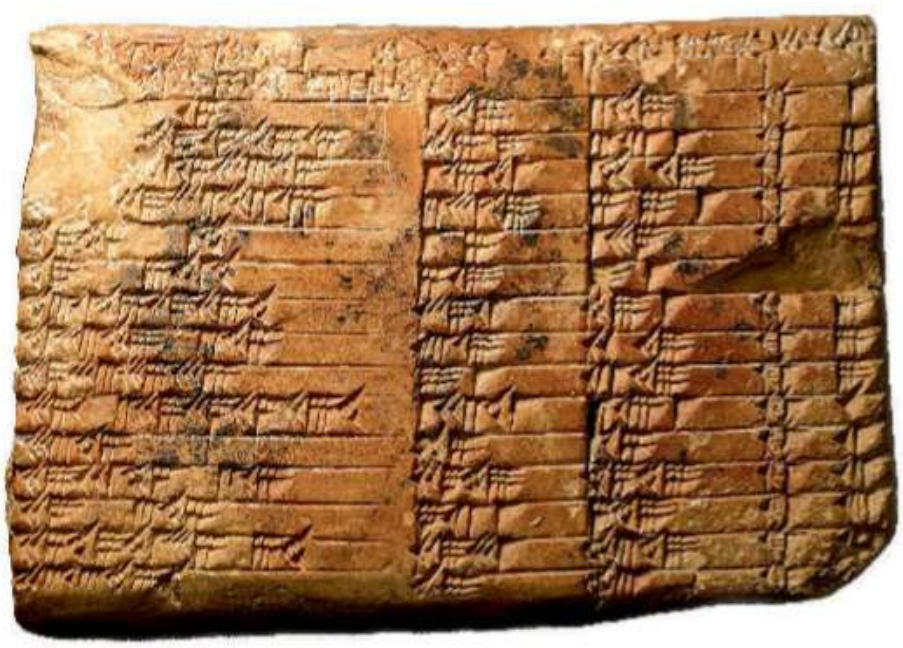
New secrets from the tablets are constantly being revealed. In 2017, a small, 3700-year-old tablet known as Plimpton 322 was revealed as the world's oldest trigonometric table, showing that the Babylonians – Akkadian-speaking people living in central and southern Mesopotamia – not the Greeks, were the first to study trigonometry. And last year, a new analysis of a tablet excavated in Iraq in 1894 showed that the Babylonians calculated with triangles centuries before Pythagoras. Yet with only around 75 people who can read cuneiform fluently, the majority of tablets lie unread, gathering dust in the back rooms of museums.

One issue is that cuneiform is incredibly complex. "The script is very ambiguous. There is no single way of writing a word," says Jiménez. In addition, most of the tablets are incomplete. The majority of cuneiform tablets are broken, chipped or smashed to pieces. Often, the edges have crumbled away, leaving stories without beginnings or ends, or with gaps in the narrative.

This is the case for the world's oldest surviving royal library, that of King Ashurbanipal of the Assyrian Empire. In the city of Nineveh, close to modern-day Mosul in northern Iraq, Ashurbanipal assembled a vast library of written works from across Mesopotamia. This amounted to 30,000 tablets, containing everything from rituals, medical encyclopaedias, astronomical observations and the exploits of royals. The writer H. G. Wells called it "the most precious source of historical material in the world", but it was reduced to rubble and burned when the city was sacked in 612 BC. I see evidence of this first-hand during my trip to the British Museum, where the remnants of this library are now stored, their blackened scorch marks still visible.

Piecing these fragments together is like assembling a number of complex jigsaw puzzles whose pieces have become jumbled up, with no picture on the boxes to tell you what to aim for, says Jiménez. What's more, fragments from the same tablet can be scattered around the world. "There's a tablet where there's a piece in Chicago, which joins a piece in Berlin and a piece here," says Finkel. Putting the puzzle back together is a painstaking process that relies on luck and memory. It took more than 100 years to identify the beginning of the *Epic of Gilgamesh* in a small fragment stored in a museum drawer, for instance. But now computers are involved, things are changing.

The Fragmentarium, part of the Electronic Babylonian Literature project, set up by



AGEFOTOSTOCK/ALAMY

Plimpton 322, a Babylonian clay tablet containing ancient mathematics

Reading the signs

Cuneiform would probably never have been deciphered without the Behistun Inscription. This trilingual monument high up an inaccessible mountain in Iran is the cuneiform version of the Rosetta Stone, another ancient trilingual text that proved to be the key to cracking Egyptian hieroglyphics.

The Behistun Inscription was carved around 520 BC to commemorate a rebellion quashed by the Persian King Darius, with versions in three different cuneiform languages – all undeciphered at the time when Western explorers first climbed up some wobbly ladders to make copies of it in 1764.

The first of these languages to be cracked was Old Persian. From the way that names such as Darius were written, another script on the monument could be deciphered. This turned out to be Akkadian, an extinct language spoken in ancient Mesopotamia (see main story). "The Akkadian tongue gradually gave up its secrets," says Irving Finkel at the British Museum in London. "Without that key, I don't think anyone could have ever done it."

From there, it was relatively straightforward to crack the original cuneiform language – Sumerian – using the many bilingual texts where scribes had written in Akkadian and underneath had added a Sumerian translation.

Jiménez in 2018, is using AI to reassemble Ashurbanipal's library and other great collections written in cuneiform by working out which fragments belong together. To do this, Jiménez is using algorithms developed to compare different variants of gene sequences, based on the fact that there are often multiple copies of the same text with minor variations. The AI can be trained on transliterations of these texts, in which cuneiform characters have been written in the Latin alphabet according to the way they sound (in the same way that Chinese characters can be written in Pinyin, their Mandarin pronunciation). The AI can then predict which cuneiform signs are likely to be in the missing segments. It can also search for a particular cuneiform sign in a huge database of fragments.

In 2019, this approach assisted with the identification of several missing pieces of the *Epic of Gilgamesh*, as well as revealing a new genre of ancient literature: a text consisting of parodies (including jokes about donkey dung) that was used by school children to help them learn to write. And together with Anmar Fadhil at the University of Baghdad in Iraq, Jiménez is also piecing together another previously unknown genre, a hymn to a city, in this case the city of Babylon, featuring details of temple life and cultic prostitutes.

Then last year, in the world's first fully autonomous cuneiform fragment identification using AI, a missing piece of the famous *Poem of the Righteous Sufferer* (which explores the question of why bad things happen to good people, and seems to be a precursor to the biblical Book of Job) was identified. "Humans would have missed this," says Jiménez.

Other researchers have turned their attention to the seemingly mundane administrative tablets. "There's a multitude of small receipt texts – written traces of transactions that occur between different institutions such as temples or the palace of the local ruler, or among individuals such as merchants," says Émilie Pagé-Perron at the University of Oxford. Collectively, they hold a wealth of information that cuts to the heart of the ancient civilisations of Mesopotamia. Sumerian texts, for instance, often contain the name of individuals and dates, meaning it is possible to trace a person's role in society. For instance, 80 tablets known as the Mama-ummi archive, dating from around 2300 BC, show that a female supervisor named Mama-ummi was in charge of a team of 180 weavers, and that there were surprisingly varied job opportunities for women at the time.

SHUTTERSTOCK/VIACHESLAV LOPATIN

A wall relief of King Ashurbanipal's lion hunt (above), and a depiction of the cuneiform poet Enheduanna (below)

HOBERMAN PUBLISHING/ALAMY

"People say the first half of human history is only recorded in these tablets"

To help wade through this sea of administrative information, the Machine Translation and Automated Analysis of Cuneiform Languages project was set up in 2017 by Heather Baker at the University of Toronto, and coordinated by Pagé-Perron. In the most recent experiments, different algorithms trained on 45,500 transliterated phrases, each consisting of up to 19 words, were tested for their ability to translate Sumerian words into English. Results published last year show that one particular algorithm could translate with an accuracy of 95 per cent. The system also pulls out key information from the texts, identifying categories such as people, places and gods.

Last year, computer scientist Gabriel Stanovsky at the Hebrew University of Jerusalem and his colleagues found a way to predict the text on missing parts of fragments, in a similar way to that of automatic prediction of words on mobile phones. They used a deep-learning AI, feeding it transliterations from 10,000 cuneiform tablets, written in Akkadian, and found that it could suggest contextually correct words to fill the gaps with an accuracy of 89 per cent.

Another potential application of AI is the dating of tablets whose origin is unknown. ›

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Cuneiform tablets can be viewed at the British Museum

WORLD HISTORY ARCHIVE/ALAMY; DINENDRA HARIA/ALAMY

"If we know the dates for certain documents, we can train the algorithm to predict the missing dates for others," says Stanovsky.

Deciphering cuneiform from its transliteration is one thing. Reading the cuneiform characters themselves is quite another. Not only does the cuneiform script evolve over time, but spellings vary considerably, and the script was also used for different languages at different times. "The other thing to keep in mind is we're dealing with handwriting from individual scribes," says Miller Prosser at the University of Chicago. On top of this, there are no gaps between signs, so it is difficult to work out which group of wedges forms a character. And whereas the Latin alphabet contains 26 letters, there are more than 900 different cuneiform signs, which can appear remarkably similar.

Despite this, computers are beginning to make inroads into reading cuneiform signs, using the same kind of computer vision systems used for text recognition. For instance, Prosser and his colleagues have trained a machine learning system called Deepscribe to detect signs on thousands of tablets from the Persepolis Fortification Archive – a trove of administrative texts written in the Elamite language from around 500 BC, found in a fortification wall. "The ability of a computer to identify the boundaries of a sign and draw a box around it is a huge achievement on its own. No one usually knows where one sign ends and the next sign begins," says Susanne Paulus, also at the University of Chicago and part of the team that carried out this work.

Instant translation

The hope is to eventually link sign recognition systems with modern language translation systems. This would mean that we could take a picture with our phone of a tablet in a museum and get an instant read-out of what it says.

None of these efforts would be possible without large digital databases of texts to provide as much data as possible to train algorithms – so they can learn, for example, which words are likely to be written next to each other. Yet, of the half a million cuneiform texts in the world's museums, only half have been transliterated or translated, and only around 100,000 are available digitally. Efforts such as the Cuneiform Digital Library Initiative and Electronic Babylonian Literature project are now making great strides to boost these digital archives.

"One problem is that we are dealing with handwriting of individual scribes"

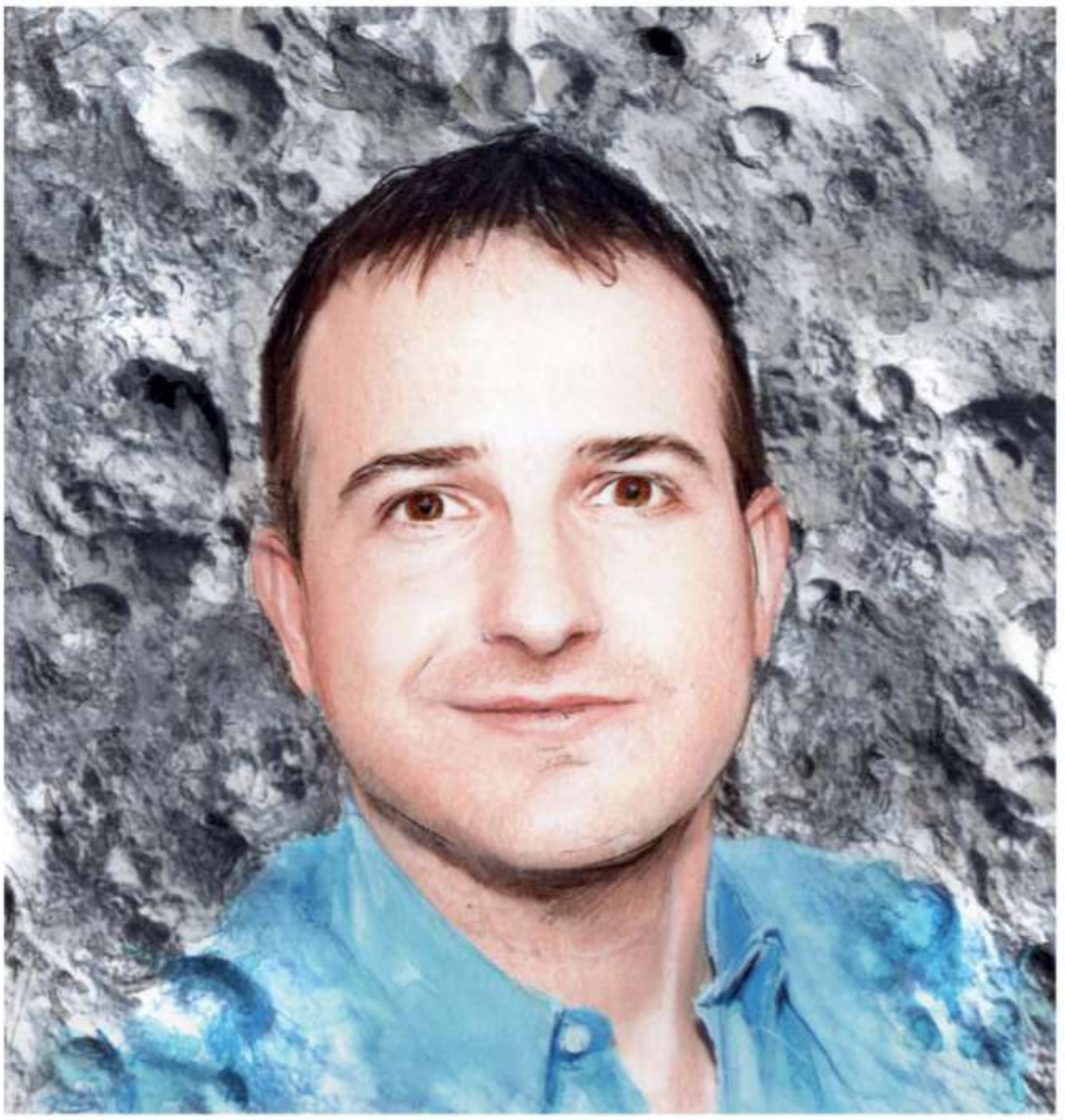
"Having the tools to digitise large volumes of text brings a lot of new information and new connections to scholars," says Shai Gordin at Ariel University, Israel. "I think the next big breakthrough will come once we can put this information in a large network of connections. This way, we can build a portfolio of the life of ancient people."

That process starts with the painstaking work of taking high-quality images of all tablets held in museums and private collections around the world. That is exactly what is going on behind me at the British Museum, where images of all 40,000 smashed pieces of Ashurbanipal's library are being captured as part of the Electronic Babylonian Literature project. In a special desktop photo studio, photographer Alberto Giannese takes six images of each cuneiform tablet – front, back, top, bottom and sides. The text doesn't always stop at the edges, says Giannese, and even distinguishing front from back and top from bottom can be hard.

The six images are then automatically stitched together by computer software and deciphered and translated by cuneiform experts such as Jiménez. By 2023, the entire collection of images will be available to the public. Not everyone can visit the secret back rooms of museums, but soon we will all be able to view Ashurbanipal's library and many other long-lost cuneiform texts from the comfort of our homes.

As my visit to the arched library of the British Museum ends and I join the crowds thronging to the exhibitions, I feel blown away at what I have just experienced – travelling back in time to witness the written thoughts of people from thousands of years ago, then back to the future to see these fractured ancient texts in the process of being reassembled again and decoded, this time in the digital realm. I think Ashurbanipal would be proud. ■

Alison George is a feature editor at *New Scientist*



NABIL NEZZAR

Blasts from the past

Ludovic Ferrière is one of the few scientists searching Earth for undiscovered impact craters from asteroids and comets. He tells Joshua Howgego why it is so important

CRATERS caused by the impact of asteroids or comets long ago are more common on Earth than you might think. They are just a good deal trickier to locate than those peppering the barren, unchanging surface of the moon. However, finding them can reveal details of prehistoric events that have had a lasting impact, as typified by the crater left behind by the asteroid impact that ended the reign of the dinosaurs. Geologist Ludovic Ferrière is the curator of the meteorite collection at the Natural History Museum Vienna in Austria, but he has a sideline in crater hunting – a difficult and dangerous pursuit that has taken him to some of the world's most remote places and even seen him spend time in jail.

Joshua Howgego: Why do you want to find undiscovered craters?

Ludovic Ferrière: What motivates me most of all – apart from the adventure of travelling to these remote places – is the possibility of making a new discovery. This is nothing unusual we humans want to discover new things, we are a curious species.

From a scientific point of view, people get excited about impact craters because we now know that one single asteroid impact can have consequences on the scale of the whole planet, like the Chicxulub impactor, a 12-kilometre-wide asteroid that hit Earth 66 million years ago near where the coast of Mexico is today. It left behind a crater roughly 180 kilometres wide – one of the largest confirmed impact structures of its kind – and led to the extinction of 75 per cent of all the plant and animal species on the planet at the time, including all non-avian dinosaurs. It changed the course of ›

evolution on Earth. If it hadn't happened, we wouldn't be here. So finding new craters on Earth helps us better understand the history of our planet's bombardment and the consequences for the environment – close by or at the planetary scale, as well as in the atmosphere.

Of course, it's also interesting to document craters to better understand the physics of these huge impacts, for example, how rocks behave and get ejected from them. There are economic reasons to hunt them, too. Quite a large number of impact craters are associated with resources such as nickel or hydrocarbons, though that is not really my main concern.

Crater hunting covers quite a lot of ground, then, no pun intended.

Yeah. Another important aspect is that craters act as traps for sediments. You have this depression that you can date precisely, from radioactive isotopes, for example, and this then starts to fill with sediments from a known time in the past. There have been a few cases where these craters have formed in places where sediments don't otherwise accumulate, making them sources of unique climate records.

One example of this is the El'gygytgyn crater in north-east Siberia, which was drilled by the International Continental Scientific Drilling Program in 2009. Samples from this area that provide a record of the past climate are very rare, but this crater provided an unbroken record of 2.8 million years of Arctic climate change.

How many craters do we know of on Earth and how many are left to find?

Some colleagues and I are working on reviewing this at the moment and centralising all the data on craters under the umbrella of the Meteoritical Society. I usually say the number of known craters is "200 plus a few" because there are a few that we are fairly sure are impact craters, but they are not quite confirmed yet.

On the moon there are more than 1 million impact craters with a diameter greater than 1 kilometre. However, we don't expect to find as many as that down here. We have plate tectonics on Earth, and this means most of the oldest rocks and early impact record have been erased. Also, weathering and so on buries craters, so the oldest ones are either not preserved or completely buried, and you need to drill to get to them. I think we have probably already found most of the really big craters. But there may be dozens, if not hundreds, of smaller ones left to find.

How do you look for undiscovered craters?

Most often, I start from lists of possible impact sites. There are a lot of these out there where people have reported circular features they have found. Many of them are obviously volcanoes or whatever. But in a few cases they are good impact crater candidates. I start from there, looking at satellite images, geological maps and other publications to compile all the available information. Very often, these things are in remote places, which is why the data available is quite limited. Then you have to go out and look for the rocks that can prove this is an impact crater.

During an impact, you have a huge release of energy and searing temperatures, which shapes and transforms rocks and minerals, so they are quite different from what you would expect of their original environment.

One thing I look for when in the field is shatter cones, which are rocks with distinctive cone-shaped striations on their surface. We know these are only formed in nature during a meteorite impact, due to the propagation of shock waves that generate this unique fracture pattern. These are the only rocks that, if you identify them in the field, you can say, "Bingo, I found a new impact crater." They are exciting to find.

The other thing you do is collect samples and take them back to the lab where you can use a microscope to look for telltale minerals called shocked quartz – quartz grains containing deformations. I get samples sent to me from people all around the world. Sometimes people who are not necessarily geologists send me samples from a crater they think they have discovered. By characterising the shocked quartz grains, we can not only confirm it is an impact crater, but also do things like estimate the shock pressure [the forces the rock experienced due to the impact] – we ideally want to be able to describe exactly what happened in these events.

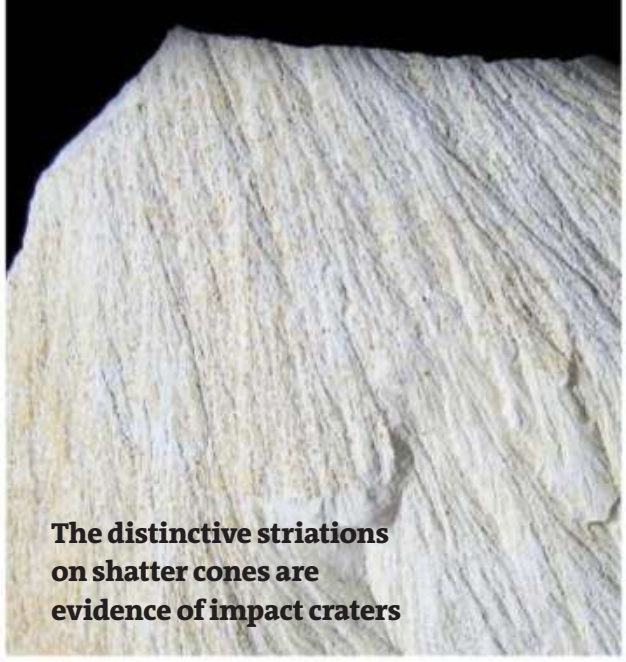
I have just published results about a 7-kilometre-wide structure known as Nova Colinas, in Brazil, which has long been a suspected impact crater. My collaborators and I have found shocked quartz grains, which prove that it is indeed an impact crater, the 11th known in the whole of South America.

Can anyone get involved in hunting craters?

There is a French citizen science platform I am involved in called Vigie-Cratère [which translates as "Lookout for craters"]. We wanted to start from scratch and provide everyone with access to this very specific satellite imagery, so-called shaded relief, which helps you see circular depressions invisible on standard satellite imagery. We have definitely found a few good crater candidates through this method.

I also want to use artificial intelligence for this work. There were a few attempts decades ago, but it didn't really work. If you just ask AI to look for a circular feature it finds them everywhere and circles a lot of rubbish; sometimes I think this job would be easier if impact craters were square. The idea now

"These are only formed in nature during a meteorite impact"



The distinctive striations on shatter cones are evidence of impact craters

JOHANNES BAIER (CC BY 3.0)

MARSHALL IKONOGRAPHY/ALAMY

SHUTTERSTOCK/ANA MONTANO

SHUTTERSTOCK/MATT DEAKIN

Crater lakes on the Portuguese island São Miguel (top); a partly frozen crater on the Estonian island Saaremaa (bottom left); Wolfe Creek meteorite impact crater in Western Australia (bottom right)

is to train an AI on the citizen science data, which should make it more effective.

What is it like hunting craters out in the field?
In 2013, some colleagues found a possible impact crater on satellite imagery. It was 7 kilometres in diameter in eastern Gabon, right next to the border with the Republic of the Congo. In 2019, my PhD student and I decided to go there to get rock samples. After crossing the whole of Gabon, we reached the proposed impact site and were told that we were actually in Congo. The border is obviously not as clear as it seems on maps and GPS. We did not have permission to be in Congo and were arrested by some police officers. Luckily, before being taken to a jail, I asked if I could take a shower. They let me do that, but I didn't really want to take a shower – I wanted to go down to a river and collect a few samples of rocks and sand.

How did you manage to conceal those in jail?
I just put the samples in with my belongings and they never checked. We were in jail for four days. When we got back, I looked at the sand under a microscope hoping to find some shocked quartz grains. But we didn't find anything and so we haven't proved that this is an impact crater yet. I need to go back there.

You have had more successful expeditions, right?
The most exciting one was about 13 years ago, when we went to the Democratic Republic of the Congo (DRC). From satellite images, the crater shows up as an amazing, circular, complex feature that is 17 kilometres in diameter. When you see something that big and with such a characteristic morphology, I mean, it cannot be anything else except an impact crater. No one had confirmed it, though, because the DRC is not a place you generally go for holidays. A few weeks before the first time I had planned to go, my permission was withdrawn due to security threats.

But I went the year after, in 2010, with a local geology student. It was in a really remote place; we went by foot for the last 25 kilometres because there was no way to approach the structure with a four-wheeled car. On the second day, we found shatter cones. I have a picture where I'm smiling because I know at that moment that I have discovered impact crater number 182. I went back again in 2013 to find more rocks that we could use to try to date the crater.

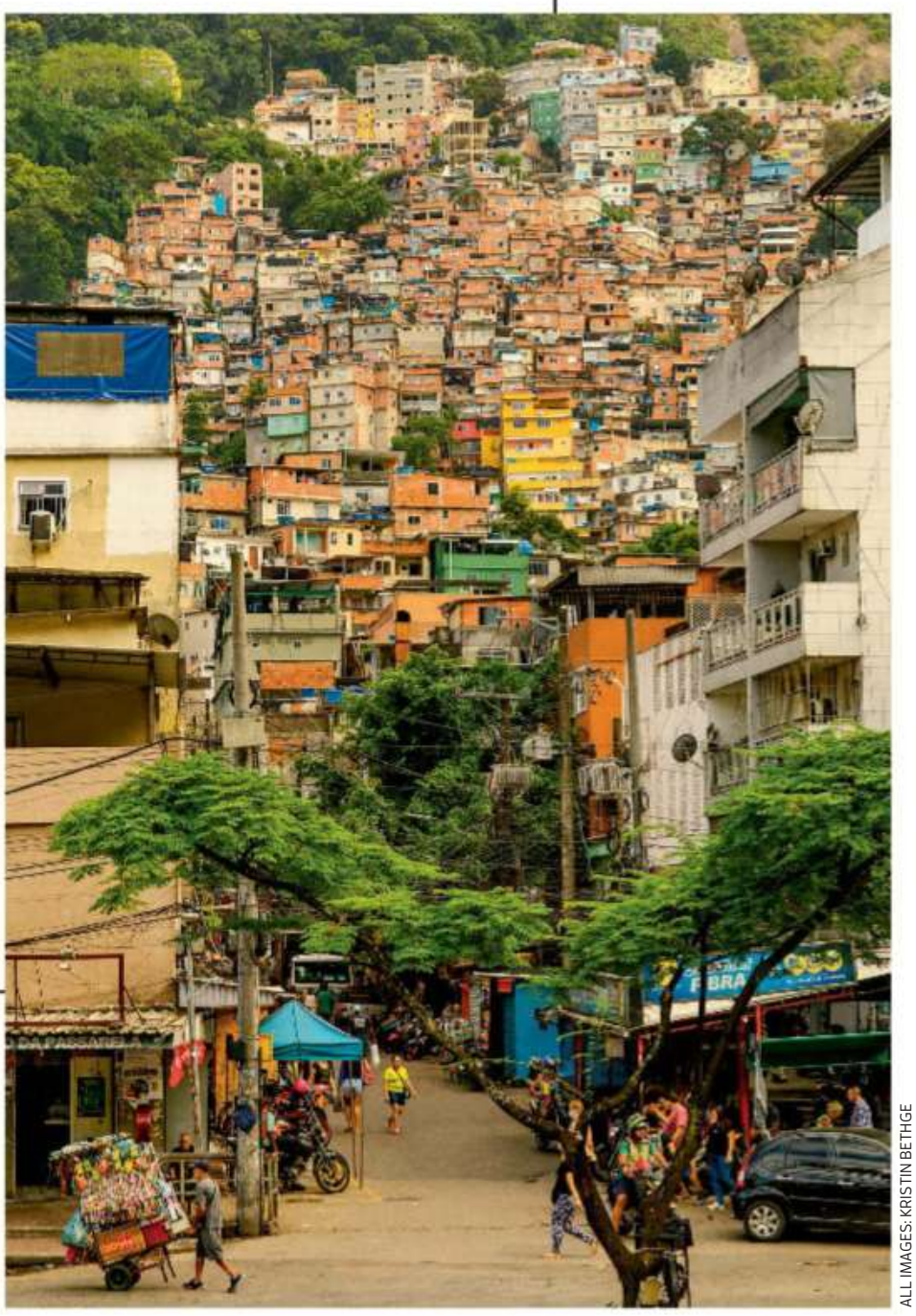
It sounds like quite an adventure.
Later on, I wanted to write my name on a tree in the centre of the crater. I was using my geological hammer to knock the letters into the wood – and when I struck the tree a snake fell out of the branches above and onto the student standing next to me. Thankfully he was fine.

What have we found out about that crater?
First of all, we have confirmed that it is an impact crater, a rather large one, and still to date the only confirmed impact crater in the whole of central Africa. We have been working to date it and that's taken a very long time. We know that the rocks in which the crater formed are at maximum about 575 million years old, so the crater must be younger than that. To be able to put an exact age on a crater is quite hard because you need to find a rock that was completely melted during the impact, which allows atoms to diffuse between the rock and its environment so that its radioactive clock was reset. We are in the process of publishing our latest results on this – it takes a lot of careful work to be sure that we date the impact and not something else, but we think that we have a good age for it now. ▮

Joshua Howgego is a features editor at *New Scientist*

Rio, bravo

Fabian Federl heads into one of Rio de Janeiro's largest favelas to discover how a retired German dentist and a group of children have become a crucial part of Brazil's fight against infectious disease



ALL IMAGES: KRISTIN BETHGE

Complexo da Maré, home to 130,000 people, is one of Brazil's largest collections of favelas

VITÓRIA LAÍS DE SOUZA GOMES, a shy 14-year-old with long, dark hair, pulls aside cables hanging from a lamp post and climbs on a platform with a view over her neighbourhood, Complexo da Maré. With more than 130,000 residents, this sprawl of 16 favelas, or slums, is one of the largest and most densely packed parts of Rio de Janeiro, Brazil.

Vitória jumps down and leads me into a house. It is cramped, humid and hot. Vitória pushes past her mother, into the kitchen, and pulls out an empty margarine tub from a drawer – it is her mosquito breeding station.

The tub is home to *Aedes aegypti*, the species that transmits several viral infections, including dengue, chikungunya and Zika. Dengue is the fastest spreading viral disease on the planet, with a 30-fold rise in incidence over the past 50 years. About 390 million people get infected each year and tens of thousands of those die. Brazil is the worst affected country in the world, and Complexo da Maré, with its densely packed houses and poor sanitation, is particularly vulnerable to outbreaks.

Which begs the question as to why Vitória is encouraging the insects that can spread the disease to live in her home. But Vitória's mosquitoes are different. Her breeding station is part of a unique anti-mosquito movement dreamed up by a German dentist and brought to life with the help of the Brazilian Ministry of Health and hundreds of local children. From such humble beginnings, it is now a crucial part of the country's most successful anti-dengue programme, one that could inspire much-needed action to save lives globally.

I am in Complexo da Maré to find out more, to discover how this movement is setting an example to other hard-to-access neighbourhoods on how to defeat deadly

viral infections – in Brazil and beyond.

The story starts in 2005 with Norbert Lehmann. The recently retired German dentist was visiting a clinic in Complexo da Maré, donating dental X-ray equipment and offering free treatment. During his time there, a patient told him a neighbour's child was sick. Lehmann told her to bring the child to the clinic. "The next morning there was screaming outside the clinic," he says. The child had died in the night from severe fever and internal bleeding due to dengue. "This death left a mark," says Lehmann.

Dengue, Zika and chikungunya are all treatable if you catch them early enough and you have access to the right medicine. But in parts of Rio de Janeiro, particularly in the city's favelas, where houses pile on top of each other and alleys turn into tunnels, infections spread easily and healthcare is hard to come by. "Dengue originates where people live densely," says Claudia Codeço, head of virology at Brazilian health institute Fiocruz. "Once the virus goes around, you can't get it contained."

Vitória tells me about a neighbour who was expanding his second floor. She says he went away for a few days and it started to rain. Water collected in a tarpaulin on the construction site, mosquitoes laid eggs in it and thousands of larvae hatched. "First Russo was sick, then Nordestina," says Vitória, using nicknames for those affected, "then Juju, then Pardo." Within a week, everyone in the alley was sick.

When Lehmann returned to his home city of Karlsruhe, which sits beside the Rhine river, he thought a lot about the impact of dengue that he had witnessed. He then remembered a project around Karlsruhe in the 1960s whose name translates as "the association to combat the mosquito plague". "When I was a kid, I played soccer on the floodplains of the Rhine," says Lehmann. "There was always this time of day, half past four, when the sky would turn black and you'd be standing in a cloud of mosquitoes." It was the reason why the area was deemed uninhabitable back then.

Lehmann recalls the unique way that the mosquitoes were eventually controlled. Children who still went to the floodplains to play football told their parents about the areas most affected. They, in turn, alerted local administrators. Helicopters – borrowed from the likes of fire departments and the police – were used to throw crushed ice containing the bacterium *Bacillus thuringiensis israelensis* into parts of the river closest to where the children reported the plagues of insects. The mosquito larvae ate these bacteria, which made them infertile, and the problem was solved. You don't need to treat the disease if you can control the carriers.

He was convinced that children could be the answer to Complexo da Maré's mosquito problem too. Much of the neighbourhood is controlled by gun-wielding gangs, meaning adults who don't live there are unable to come in to educate the community about mosquitoes. But there were hundreds of children who could walk freely around the neighbourhoods. Over the next decade, Lehmann raised money in Germany, and in 2014, he hired social workers within the

"In Rio, the help of local children has been essential"

A resident places a mosquito-breeding tub in their home

Residents of Complexo da Maré live in densely packed homes where disease can spread fast

complex to educate children about the role of mosquitoes in spreading disease. The children walked through the favelas, explaining to other children and adults about how to stop the spread: don't leave water standing, check surfaces after rain and so on. They educated communities about the symptoms of disease, where to get tested and when symptoms become critical. The campaign was called Heroes Against Dengue, and word spread. Within months, dozens of children, including Vitória, had joined up.

It is difficult to say how successful the campaign was at this point, as collecting data from inside complexes like Maré is challenging. However, just before the 2014 men's football World Cup in Brazil, Zika broke out across Rio. Thousands of people fell ill and hundreds of children were later born with neurological conditions directly related to infection with the virus responsible. The government didn't collect official figures from Complexo da Maré at this time, but according to anecdotal data from researchers at Fiocruz, doctors in the neighbourhood and in hospitals in the region saw fewer cases from within Maré than expected.

Yet education can only take you so far in the fight against vector–borne diseases. In 2014, an opportunity arose to possibly wipe out these diseases altogether. Shortly after the World Cup, Brazil began small trials of an anti-mosquito programme using what is known as the Wolbachia method. It involves infecting mosquitoes with a naturally occurring bacterium called *Wolbachia* from a fruit fly. This suppresses the dengue virus and others in two ways. First, the bacteria occupy the part of cells that viruses use to reproduce. "There is competition in the cell between the virus and *Wolbachia*," says Wesley Oliveira at Fiocruz. If a mosquito infected with both the dengue virus and *Wolbachia* bites you, the risk it will transmit dengue is only 5 per cent, compared with an 80 per cent chance from the bites of mosquitoes infected with the dengue virus alone. Second, when *Wolbachia*-infected males mate with uninfected females, those females will lay eggs that won't hatch. When females with *Wolbachia* mate, their offspring are born with the bacterium, no matter whether the male had it or not. Gradually, the entire population of mosquitoes become affected.

Researchers at Fiocruz breed vaccinated mosquitoes, above, which are kept in gauze-covered cages, far right. A capsule of mosquito eggs vaccinated against dengue, right

"At half past four, the sky would turn black with a cloud of mosquitoes"

This technique was originally developed by the World Mosquito Program in the early 2000s. In 2018, Australia released 3 million mosquitoes inoculated with *Wolbachia* in three North Queensland communities. By 2021, populations of mosquitoes had been suppressed by up to 97 per cent, virtually wiping out dengue in areas where the technique was most successful.

I visit Fiocruz, situated on the edge of the Complexo da Maré, where Brazil's own *Wolbachia* mosquitoes are bred. Inside its insectarium, gauze cages house millions of mosquitoes. White nets streaked with red hang from the ceiling – they are soaked in human blood, fresh from a blood bank, which female mosquitoes must feed on to form their eggs.

On the countertop, researchers place a nutritious mix of fish and liver meal, charcoal and yeast into thimble-sized holes.

Vitória Laís de Souza Gomes has been a key player in fighting infectious diseases around her favela

They drizzle mosquito eggs taken from the *Wolbachia* mosquitoes on top. These will be manufactured into thousands of small, black capsules.

Having seen promising results in smaller trials in 2014, three years later, Fiocruz began a large-scale deployment of these capsules in breeding stations in parks, railway stations and residential areas around Rio and the neighbouring city of Niterói. An analysis of the project, which compared the incidence of disease in areas of Niterói where capsules were deployed with an untreated control zone, showed a 69 per cent reduction in dengue, a 56 per cent fall in chikungunya and 37 per cent less Zika. The preliminary data suggested that the numbers would be comparable in Rio – with a few exceptions: favela neighbourhoods, including Complexo da Maré.

Dengue defenders

In 2019, Oliveira showed Lehmann Fiocruz's most recent data. Lehmann was curious as to why the programme wasn't working in Maré. Oliveira said his researchers had tried to get vaccinated mosquitoes into the neighbourhood. They installed breeding stations in schools and clinics, but those are often on the borders of the favelas. They had even tried to blow the mosquitoes over the barricaded areas of the neighbourhood with a long pipe. It was out of the question to ask the drug gangs that control Maré for permission to go further in, said Oliveira. With mosquitoes not tending to spread too far from where they breed, Maré remained undersupplied. When Lehmann heard Oliveira's explanations, he said that Heroes Against Dengue may be able to help.

After their meeting, Lehmann asked his heroes to help put mosquito eggs in places around the favelas where they knew mosquitoes liked to breed. Breeding *Wolbachia*-carrying mosquitoes has now become popular, says Oliveira – parents call Fiocruz because their children want a kit.

Back in Vitória's house, I watch as she fills a new margarine tub with water and places two black capsules inside. Her mother helps her punch holes in the lid with a screwdriver. She carries the box to the entrance of her home and stows it in the rafters. Later, hundreds of mosquitoes fly through the holes.

Today, the Wolbachia programme is considered the most successful anti-dengue measure in Brazil, says Luciano Moreira, also at Fiocruz, and Lehmann and his troop of heroes are a big part of making it work. Dengue outbreaks happen in waves, so figuring out the incidence can be tricky, but cases seem to be significantly down inside the favelas and around the city more generally, he says. In 2015, before the widespread deployment of the inoculated mosquitoes, there were 18,070 officially recorded cases of dengue in Rio de Janeiro. In 2017, this dropped to 3684, and in 2021, there were 937.

The programme is now being exported to other cities in Brazil, including Belo Horizonte, Campo Grande, Petrolina and Maricá, as well as to other countries, such as Indonesia. In Belo Horizonte particularly, researchers will probably encounter similar accessibility issues as they faced in Rio, since a similar percentage of its population live in favelas. The answer is that, where necessary, Lehmann's heroes programme will be included in the plan. "In Rio, the help of local children has been essential," says Oliveira. The approach is already being replicated in other favelas in Rio, such as Jacarézinho, one of the most violent neighbourhoods in the country.

On my last day with Vitória, she packs a small backpack and walks down an alley close to her home. It has been raining, ankle-deep puddles have formed in the asphalt, water stands in plastic plates and old car tyres. She kicks over every tin can she sees to pour out the water. The wrong kind of mosquitoes could be breeding in there.

Vitória strolls down the street, constantly greeting people. She goes door to door every week to educate people about mosquitoes. A white container building looms in the distance, a government health clinic. Just in front are heavy concrete pillars, a barricade set up by a drug gang. I stop. Young men with guns strapped to their chest stand around. On the tables in front of them lie a pile of drugs. Vitória walks past the gunmen unimpressed, bypassing the barricade. She is allowed through because she is from Maré.

In the clinic grounds stands another table. On this one are hundreds of bags of black capsules. A crowd of people are waiting for a medical appointment. Vitória hands out dozens of mosquito kits that day. She is incredibly proud of what she is doing, she says. A 14-year-old-girl from a favela, saving hundreds of lives. ■

Fabian Federl is a journalist based in Berlin. His trip was supported by the US Pulitzer Center

The back pages

Puzzles
Try our crossword, quick quiz and logic puzzle p53

***Almost* the last word**
How might space have gone from finite to infinite? p54

Tom Gauld for *New Scientist*
A cartoonist's take on the world p55

Feedback
Why roboticists find dead spiders truly gripping p56

Twisteddoodles for *New Scientist*
Picturing the lighter side of life p56

The science of cooking

Some like it hot

Fermentation sounds daunting, but **Sam Wong** reveals how you can use it to make hot sauces packed with flavourful compounds

Sam Wong is assistant news editor and self-appointed chief gourmand at *New Scientist*. Follow him @samwong1

What you need

300g red chillies, stalks removed
50g garlic, peeled
500ml water
25g salt
1 tbsp sugar
1 tbsp cider vinegar

HOT sauces are popular all over the world. Many are produced by fermentation, using microorganisms to add depth of flavour and create sauces offering more than just a kick of chilli heat.

The burning sensation comes from capsaicin, a molecule that activates heat receptors. As Clare Wilson explained in her science of gardening column a fortnight ago, *Capsicum* plants may have evolved the ability to produce capsaicin to deter mammals from eating them, but our species has developed a perverse taste for the pain it brings.

If you are following Clare's tips for growing chillies at home, you might have a bumper crop ready for turning into fermented hot sauce. If not, making it with shop-bought chillies is just as rewarding.

The basic idea when fermenting any kind of food is that you add salt to encourage certain microbes to grow and produce acid. The salt and the acid inhibit the growth of bacteria that cause food to spoil, so fermented foods tend to keep for many months.

In fermented cabbage dishes like kimchi, bacteria that produce lactic acid, such as *Lactobacillus* and *Leuconostoc*, are key players in the process. But this isn't the case when fermenting chillies, according to a study by researchers in China last year. They found that acetic acid and malic acid were the main acids in chilli fermentation.

The researchers found over 100 volatile compounds – those that are easily vaporised and reach our noses – in the fermented chillies. These included 43 esters, a class of molecules known for their fruity aromas, that became dramatically more concentrated during the fermentation process.

SHUTTERSTOCK/FOTEMA

Through genomic analysis, the researchers then identified *Rosenbergiella* and *Staphylococcus* as the most dominant types of bacteria in the fermented samples, but little is known about how they contribute to flavour. They also found a diverse range of fungi, including the yeasts *Hyphopichia*, *Kodamaea*, *Meyerozyma* and *Debaryomyces*, which are found in other fermented foods such as sourdoughs and cider vinegar.

To make your own fermented hot sauce, you can use any kind of chillies you like – ideally ones that haven't been treated with pesticides. It is a good idea to taste them first rather than spend two weeks fermenting only to discover that your sauce is too hot.

After removing the stalks from your chillies, pack them into a sterilised jar with the garlic. Dissolve the salt in the water, then pour this into the jar too, making sure the chillies are submerged. Now, seal the jar and leave it at room temperature for one to two weeks, opening it every few days to let gas escape.

When the chillies taste sour, your ferment is ready. Strain it, reserving the liquid, then blend the solids while adding enough liquid back in to make a smooth sauce. Add sugar and vinegar to taste – then store in the fridge. ■

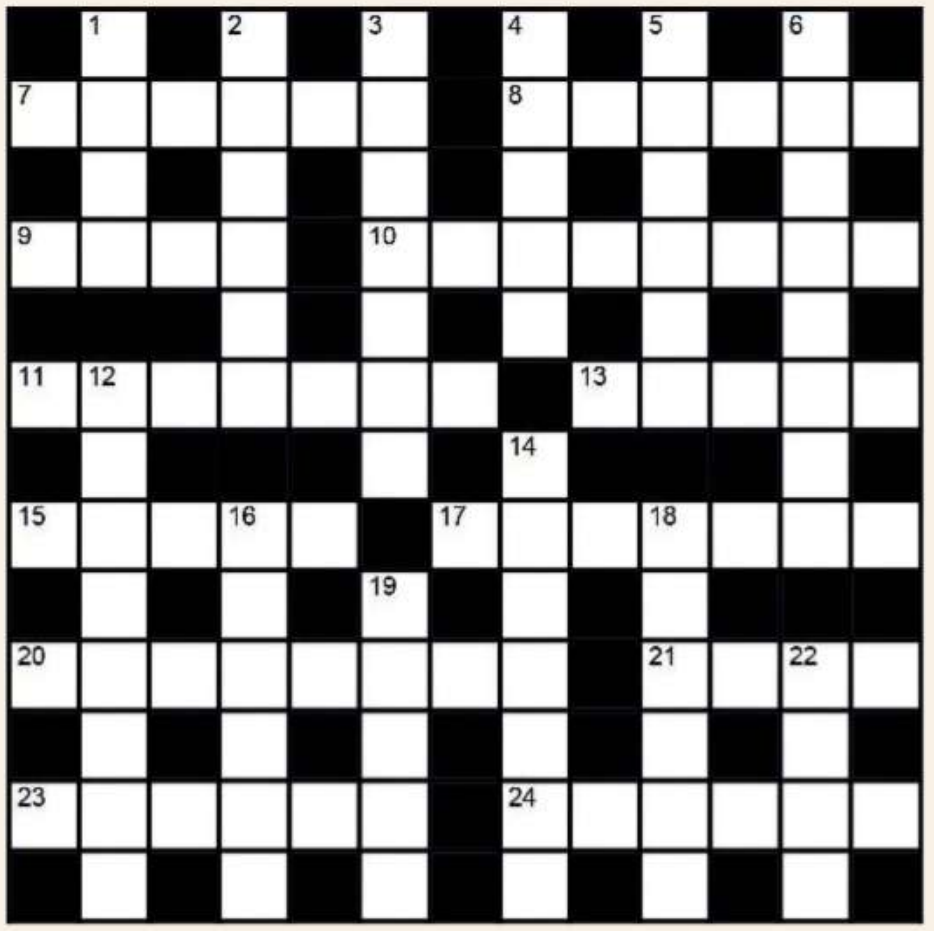
The science of cooking appears every four weeks

Next week

Stargazing at home

These articles are posted each week at newscientist.com/maker

Cryptic crossword #89 *Set by Wingding*



Scribble zone

Answers and the next quick crossword next week

ACROSS

7 Cat starts to appreciate taste of fruit (6)
8 Included in talk, a new hydrocarbon (6)
9 Ring inside little 21 inhabitant (4)
10 Iterates original essay (8)
11 Theory about mishaps: clumsy lad's possessed by pig (4,3)
13 Relative mostly making soup (5)
15 Perceive meaning (5)
17 Swimmer's pod frolicking in story (7)
20 Most clever fish briefly getting ahead of menace (8)
21/5 Down Insect darkens top when stressed (4,6)
23 Rodent returned waterproof coat – cars drive over it (6)
24 Witty remark to slay record label (6)

DOWN

1 Double nitric oxide? That's not acceptable (2-2)
2 Insect's iron-carriers out of energy (6)
3 See 4 Down
4/3 Down Having eaten nothing, superhero follows server who's lost one insect (5,7)
5 See 21 Across
6 Refined oil is not sugar (8)
12 Cost more than chief executive (8)
14 Johnson glugs wine with last of cheese – it's a distraction (7)
16 21 inhabitant is quiet, softly going around edge (6)
18 Transform dog at start of experiment (6)
19 21 inhabitant's drain to the ear (5)
22 Physicist dropping on 21 inhabitant (4)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #163

1 Which force dictates the direction of a hurricane's spin?

2 What is the densest moon in our solar system?

3 Physeteridae, Kogiidae and Ziphiidae are all families in which group of animals?

4 How many prime numbers are there between 1 and 100?

5 Halophiles are organisms that can exist in areas with high concentrations of what?

Answers on page 55

Puzzle
set by Rob Eastaway
#179 Martian food

It is the year 2100 and the Mars pioneers have built an agri-bubble in which they will be able to cultivate their own food. The crop is a form of grass that grows at a steady rate and can be harvested and turned into nutritious protein snacks (yum!). Now it is time to populate the planet.

Scientists have figured out that if there are 40 adults living in the bubble, the crop will only feed them for 20 days. However, with only 20 adults, the crop will keep them going for 60 days – so half as many adults can survive for three times as long! Why? Because without overharvesting, the crop is able to replenish itself.

Of course, the pioneers want a food supply that keeps the population sustained indefinitely. Based on the numbers above, how many people should be in the first Mars cohort?

Solution next week

Infinity origin

The universe could be infinite in size, but how is it logically possible to attain an infinite size from a finite initial state?

Antonio Padilla
University of Nottingham, UK
If the universe has only existed for a finite time, then we couldn't actually have an infinitely large universe emerging from a finite initial state.

However, we don't know if the initial state of the universe was finite or not. It could have been infinite from the very beginning. There is no cosmological observation that rules this out.

The cosmic microwave background radiation encodes information about the shape of the universe, but this still leaves us with a number of possible scenarios. The universe could be finite like a gigantic sphere, doughnut-shaped (a torus) or an infinite, three-dimensional plane or a saddle shape. We just don't know. All we know is that it is big!

"The universe could be finite like a gigantic sphere, or doughnut-shaped, or it could be like an infinite, three-dimensional plane"

Eric Kvaalen
Les Essarts-le-Roi, France
It is a loaded question! No one says that the universe is infinite now but started from a finite initial state. The problem is that we can't know whether the universe is finite or infinite. We can't see beyond a certain distance, which has been increasing ever since the big bang.

As far as we can see, the number of galaxies per unit volume seems constant, independent of distance. It is hard to imagine space just ending somewhere.

An alternative, spatially finite universe, proposed by Einstein, is one that is like the surface of a sphere but three-dimensional. But there is no evidence of the curvature that model would entail.

Hillary J. Shaw
Newport, Shropshire, UK
The universe could appear infinite if it is really the three-dimensional surface of a very large, four-dimensional hypersphere.

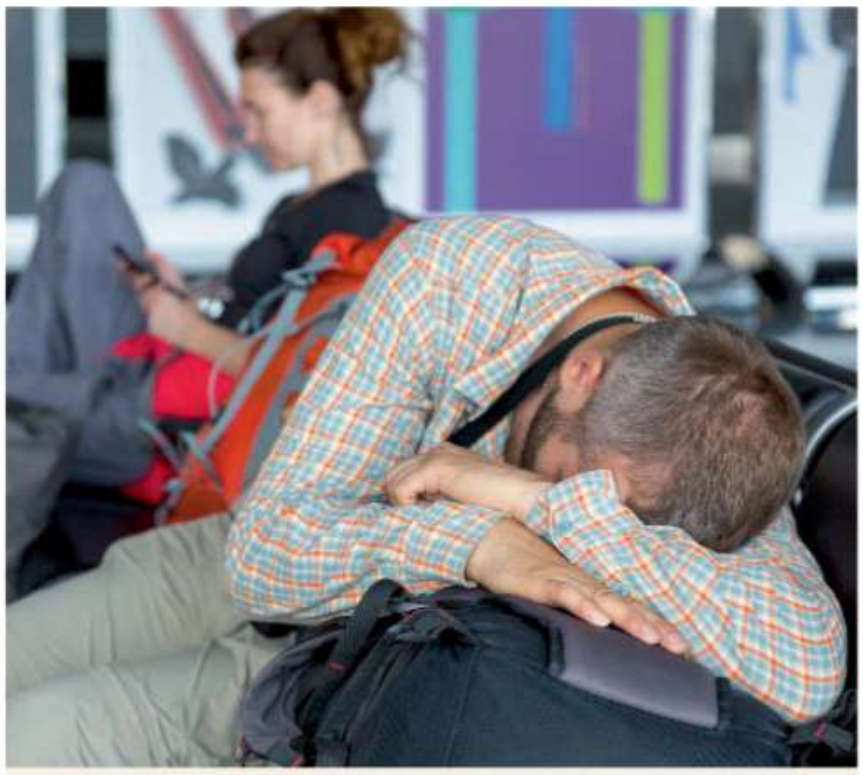
The pace of expansion would be fast enough to preclude us "seeing the back of our own heads", as the light travelling that way could never reach us. This would be analogous to Earth's 2D surface appearing endless, as it is the surface of a 3D sphere.

Denis De Volder
Paris, France
First, we must answer the question: why wouldn't it be logical for the universe to have expanded into infinite space while it was finite in size at its origins?

The answer to this might not lie in the realm of physics, but rather in semantics and our cognitive ability to imagine beyond our near environment.

And what do we mean by the universe? Here, the universe wouldn't be defined as the visible one, rather as the potential everlasting empty space in all directions beyond the visible universe.

Hector Ruiz
El Monte, California, US
If the universe is infinite, then the statement "finite initial state" is false – meaning that the big bang was just a part of the infinite state of the universe, not the beginning of it.


SHUTTERSTOCK/ALEX BRYLOV

This week's new questions

In a spin **Is jet lag worse if you travel east rather than west? Does going with or against the rotation of Earth have an impact?** ***Grace, Lucy and Sam Liubinskas****, Sydney, Australia*

Hairy issue **Why do humans have pubic hair, when other "hairless" mammals, like pigs and elephants, manage without it?** ***Jim Stone****, Great Hucklow, Derbyshire, UK*

Does it make a difference to jet lag if you travel eastwards rather than to the west?

Bryn Glover
Ripon, North Yorkshire, UK
I feel that a problem arises when the words "finite" and "infinite" occur in the same sentence linked by nothing more than a mere verb.

A finite universe is a tangible entity that can be measured and defined. Infinity isn't a number or a quantity, it is a concept that is useful in mathematics, so long as a means can be identified for finally eliminating it in calculations.

@LandwehrJobs
via Twitter
I picture it like this: the universe is like a balloon and while you travel from the centre to the fringe, it expands. So it looks like infinity. At some point, it snapped back and compressed all the matter back in one tiny spot.

@magnusiscariot
via Twitter
The logical answer would be that it isn't possible. Either the universe isn't infinitely large or was never in a finite initial state.

Technically, we only see the universe as expanding from a smaller state. Perhaps it is our understanding of finite and infinite that needs work.

@PauloXR7
via Twitter
If the universe were finite, then it would have an edge somewhere. Ask yourself "what is on the other side of that edge".

Crocodile power

How do crocodiles maintain their explosive power despite being motionless for long periods, while if I am sedentary, my muscles weaken?

Stephen Johnson
Eugene, Oregon, US
Reptiles, such as crocodiles, and mammals, such as humans, have two basic types of muscle fibre.

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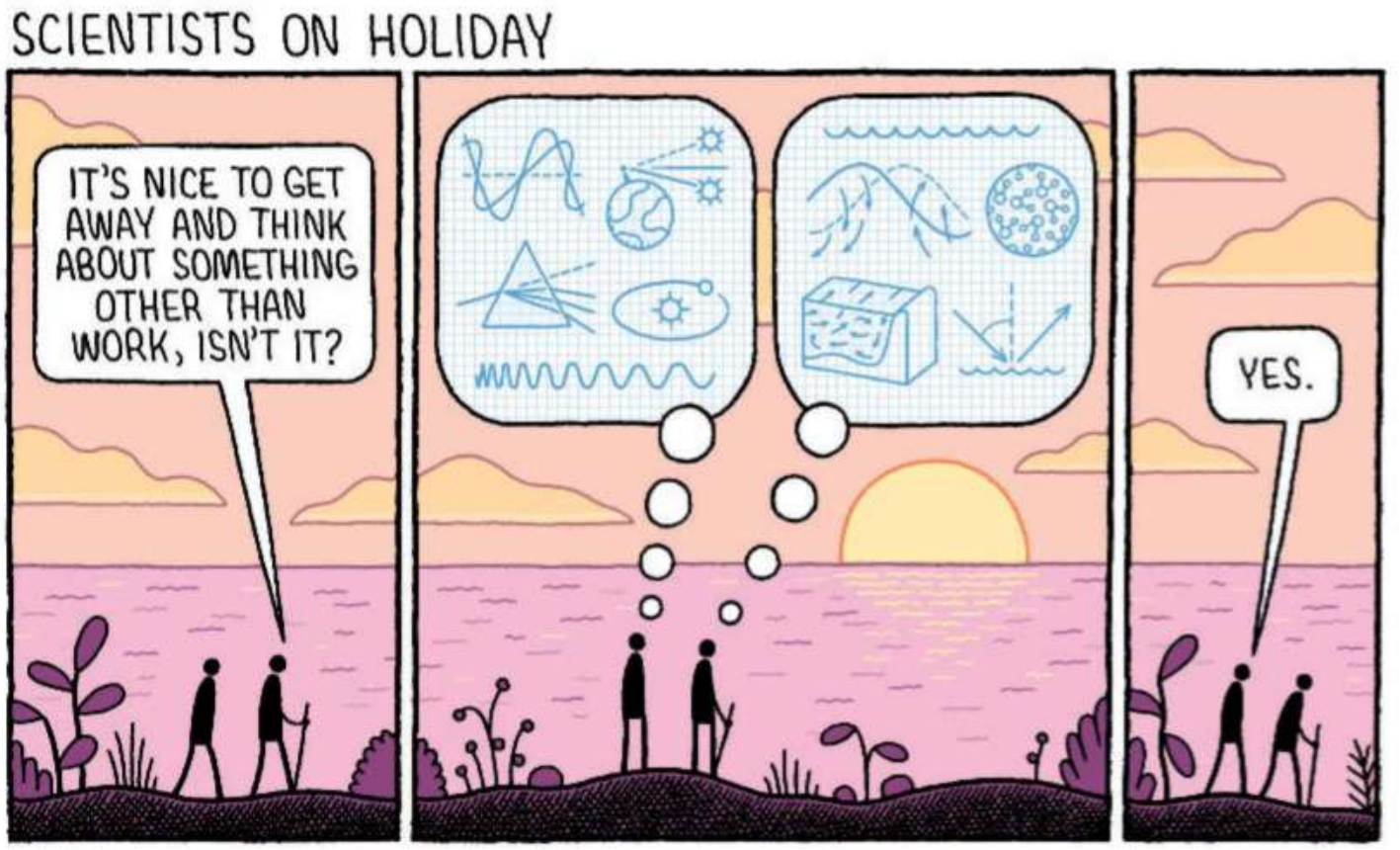
Tom Gauld
for New Scientist



Slow-twitch muscle fibres support continual exercise and respond to endurance training. Fast-twitch muscle fibres support explosive power and respond to short, intense activity.

When humans are sedentary, their slow-twitch fibres will, over time, convert to become fast-twitch. As an extreme example, a person who is paralysed as a result of spinal cord injury will eventually convert their paralysed muscles into almost 100 per cent fast-twitch fibres.

Crocodiles only need fast-twitch muscles to capture their prey. As a consequence, their lifestyle of mostly lying in wait for prey works to their advantage.

In addition, they possess a form of super-fast-twitch muscles in their jaw to aid in applying a very large, almost instant force to anything they catch.

Finally, their legs and hips have evolved to aid them in jumping forward quickly.

What the author of this question experiences when they are sedentary is a loss of function in their slow-twitch muscles, those which support a continuous effort.

"Crocodiles only need fast-twitch muscles to capture their prey, so their lifestyle of mostly lying in wait for prey works well"

Mike Follows
Sutton Coldfield, West Midlands, UK
The secret of the explosive power of crocodiles is their fast-twitch muscles. Sprinters generally have more fast-twitch muscle than distance runners. The downside is that sprinters – and crocodiles – can't sustain their high-power output for long.

Ectotherms (cold-blooded animals, which includes crocodiles) generally feed during the day when the higher temperature enables their muscles to function better. In fact, crocodiles can have body temperatures in excess of 30°C, which is only a little lower than ours (37°C) and they change location to achieve this, for example by basking in the sun.

They also don't need to feed as often because they don't need extra "fuel" to run an internal heating system to keep their bodies warm. Consequently, they can sit and wait to ambush prey.

They are well-adapted for this, but, size-for-size, the explosive power of the crocodile is nothing compared with a mantis shrimp. This marine creature can punch its prey with a force of more than 700 newtons, equivalent to over 1000 times its own weight.

Hinged clubs at the front of its body, called dactyls, can accelerate an astonishing 10,000 times faster than an object in free fall to deliver a blow at speeds close to 100 kilometres per second. This is accomplished when the shrimp transfers chemical potential energy from its food into elastic potential energy, using its muscles to change the shape of part of its exoskeleton. A latch releases the stored energy. Humans achieve the same effect with a crossbow. ▮

Answers

Quick quiz #163 *Answers*

1 The Coriolis force
2 Io, which orbits Jupiter
3 Whales
4 25
5 Salt

Quick crossword #113 *Answers*

ACROSS 1 *Planet of the Apes*, **9** Roseola, **10** Beretta, **11** Goral, **12** Aleph-Zero, **13** Inland sea, **15** Deneb, **16** Eight, **18** Astronaut, **20** Antenatal, **23** Aural, **24** Crevice, **25** Stomach, **26** Nash equilibrium

DOWN 1 Peregrine falcon, **2** Austral, **3** Exoplanet, **4** Omaha, **5** Table salt, **6** Earth, **7** Pattern, **8** Star of Bethlehem, **14** Start menu, **15** Drop a bomb, **17** Gutters, **19** Air taxi, **21** Noise, **22** Lysol

#178 Hydra *Solution*

The monster is completely tame when all the heads show prime numbers. We can factorise 418 as 2×11×19 and 651 as 3×7×31. This leaves 113 – (2 + 11 + 19 + 3 + 7 + 31), which is 40, so the remaining heads must be prime numbers not already used that sum to 40. The only way to do this is as 17+23, so the mystery third head must have shown 17×23 = 391.

Dressing down

Time for elevenses – and what could be nicer to go with this cuppa than a cucumber sandwich slathered in Miami chef Carly Pii's proprietary Pink Sauce?

Pii's product launch wasn't the smoothest, according to the *Los Angeles Times*. A couple of misprints on her labelling left purchasers with a 444-gram bottle that provided "444 servings". Just how powerful is this condiment? Too powerful for some: the dragon fruit that lend the sauce its tang and lurid colour act rather like beetroot, and this distressed some unsuspecting consumers, come their next bowel movement. Pii duly adjusted her formula, turning her hot pink concoction into something resembling Pepto-Bismol. But it was the initial packaging for her sauce (which arrived through the post, during a heatwave, in plastic bags instead of bottles) that caused the most annoyance.

Such has been Pii's savaging on TikTok (including one social media stunt in which a "consumer" allegedly faked his own death) that a counter-movement has emerged, with champions buying her entire stock. Meanwhile, Pii has been on the case. "Y'all gotta stop this negativity," she said last Thursday, in a YouTube video that lasted a staggering 52 minutes. Now that is what we call a riposte.

Wrapped up in the game

If this is the new face of consumer activism, then no wonder Manchester City Football Club are keeping their supporters close. The Verge reports on the limited release of the club's new smart scarf, sporting wearable fitness tracker-style biosensors to help the organisation "shape more curated, customized experiences in the future" and "serve as a study in shared passion".

Giving a data-harvesting project such a fulsome description feels disingenuous to us. Feedback prefers an altogether more charming tale of intimacy from afar, courtesy of IFL Science. On the morning of 19 May 1845, an expedition led by John Franklin set sail to find the Northwest Passage linking the Atlantic and Pacific Oceans. The expedition vanished. Five years later, Richard Collinson and others set out to find Franklin and his doomed crew. For all the while they were away, from 1850 to 1855, mysterious ads appeared in the UK in *The Times* newspaper, written in a code that remained unbroken for 170 years. Now, cryptographers Elonka Dunin, Klaus Schmeh and A. J. Jacobs have used the Marryat Signal Code, used by ships to send encrypted messages to each other using flags, to decode the ads.

They turn out to be tender private messages between Collinson expedition members and their families – the assumption being that no matter how far they travelled, they would never be far from a copy of *The Times*. "Do write a few lines darling, please," one message reads. "I have been very far from happy since you went away."

Twisteddoodles *for New Scientist*

Got a story for Feedback?
Send it to feedback@newscientist.com or New Scientist, Northcliffe House, 2 Derry Street, London W8 5TT
Consideration of items sent in the post will be delayed

Perverse incentive

This is the sort of family sentiment Feedback can get behind; less so the bug (that games company Electronic Arts is even now frantically patching) that has the avatars of The Sims 4 pining for daddy – and not in a good way, according to *The Sun*.

A "wants and fears" system, introduced with the game's newest expansion pack, makes it easier for players to fulfil their sims' everyday desires – one of which is to kiss and date those closest to them. Unfortunately, the new system is ignorant of the game's long-standing prohibitions around intra-family relationships.

So sims have been pining away, unable to comprehend why their nearest and dearest won't date them. On Twitter, an Electronic Arts team member has assured us that this "is something we know about, we've reproduced ourselves, we're working on it", which is a mite less reassuring than perhaps intended.

Illegal move

Then again, the company's evident goodwill contrasts markedly with the response Sergey Smagin at the Russian Chess Federation gave a Russian state-owned news agency, after a chess robot seized and broke a 7-year-old's finger during this July's Moscow Open.

The Guardian reports that Smagin said the incident was "a coincidence", the child had "violated" safety rules and the robot was "absolutely safe". (The boy is fine, though he finished the competition wearing a cast.) Sergey Lazarev, president of the Moscow Chess Federation, was more forthcoming to the TASS news agency. Only a little, mind: "This is, of course, bad," he said.

Dead wringers

Feedback advises making robots of more forgiving materials. No sooner said than done, going by *IEEE Spectrum*'s breathless description of the latest in hydraulic gripper technology: the dead spider.

"Necrobotics" is all the rage, following the publication of a paper by researchers at Rice University in Houston, Texas. Exploiting the way spiders control their limbs by adjusting blood pressure through an internal valve system (which is why a dead spider's legs curl up – there is no pressure to balance the force of the flexor muscles), the team has been injecting air into euthanised wolf spiders and using them to lift loads 1.3 times their own weight.

Grotesque it may be, but Feedback is even now fashioning a tiny chess set.

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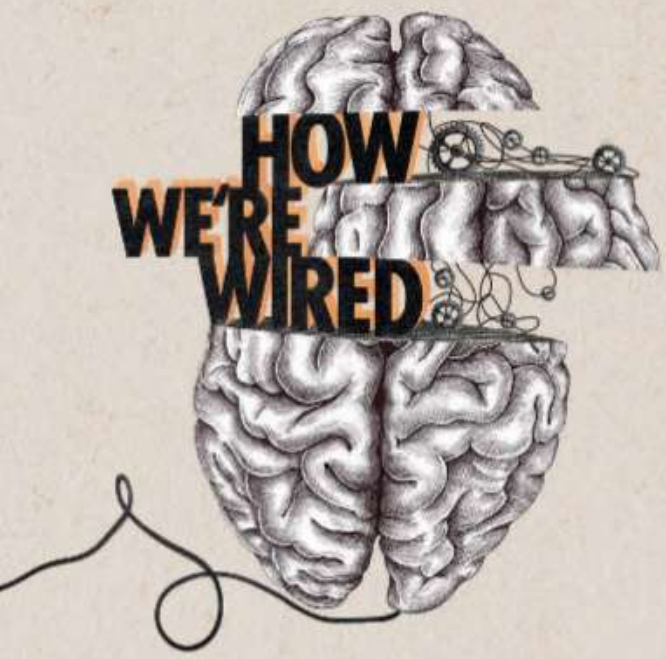

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